COMMUNITY NOISE LEVELS IN KINGSTON, NORTH BAY AND SAULT STE. MARIE

Ontario
Ministry of the Environment

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Minister

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COMMUNITY NOISE LEVELS

IN

KINGSTON, NORTH BAY AND SAULT STE. MARIE

BY

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ABSTRACT

Weekday and weekend community noise levels were monitored at a total of 105 sites in the cities of Kingston, North Bay and Sault Ste. Marie.

Sound levels (L_{90}, L_{50}, L_{10} and L_{eq}) during daytime (7:00-19:00 hours), evening (19:00-23:00 hours) and night-time (23:00-7:00 hours) are presented for eight different land-use zones. Comparisons are made between weekday and weekend levels for some of these zones.

The difference in noise levels between communities of different population sizes is studied.

ACKNOWLEDGEMENTS

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Efforts of the individuals, who have not been acknowledged personally,and who have contributed to this survey in different ways, are gratefully appreciated.

Toronto, Ontario,
June, 1976.

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Average Levels: Arithmetic average of any two of more sound level measurements.

L_{max} : Maximum dBA sound level recorded over a measurement period.

L_1 : Sound level in dBA exceeded 1% of the time during the period of measurement, corresponds to very high level intrusions of short duration.

L_{10} : Sound level in dBA exceeded 10% of the time during the period of measurement, corresponds to average level of intrusive sounds.

L_{50} : Sound level in dBA exceeded 50% of the time during the period of measurement; refers to median sound levels.

L_{90} : Sound level in dBA exceeded 90% of the time during the period of measurement, refers to ambient or background levels.

L_{eq} : The energy equivalent continuous level is that constant sound level which has the same energy as a time-varying noise during the period of measurement.

L_{NP} : Noise Pollution Level in dBA given the following expression:

$L_{NP} = L_{eq} + 2.56\ \sigma$

where, σ (Sigma) is the standard deviation, in dBA of the measured sample.

Mean Sound Levels: Arithmetic average of sound levels measured at all the sites in a land-use zone.

Site variance : Variation of sound levels between different sites of a land-use zone.

1. INTRODUCTION

Community noise can be described as a composite of outdoor sounds generated by human activity, transportation, industrial operations and commerce within a community. These sounds are known to interfere with numerous activities including speech and sleep and thus have a considerable potential for annoyance. To provide for a long term regulation of the sound environment in communities, it is necessary to determine and analyse the existing levels of sound as a starting point. Community noise studies provide such base information.

One of the earliest surveys of community noise was conducted in 1937 by the Bell Telephone Company[1]. Outdoor sound levels were measured at several hundred residential sites in Chicago, Cleveland and Philadelphia. Mean and median sound levels were measured at more than 100 sites in residential and industrial areas of Chicago during 1947-48[2]; an aircraft noise survey[3] in 1954 documented sound levels near major airports in the U.S.A.; Bolt, Beranek and Newman[4] carried out community noise measurements in Boston, Detroit and Los Angeles during 1971; sound levels were measured at several hundred sites in the City of Tokyo[5] and its suburbs in 1965. Technical papers by Soroka[6] and the U.S. Environmental Protection Agency[7] present summaries of such studies in various countries.

In Canada, the Greater Vancouver Regional District supported a community noise survey[8] in 1971. The survey incorporated approximately 10,000 individual noise measurements. Alberta's Department of the Environment in 1972 announced community noise measurements in Calgary and Edmonton. A summary of the Edmonton Noise Survey[9] has been reported recently.

The Ontario Ministry of the Environment began its involvement in community noise measurement during the summer and fall of 1972 when it co-ordinated a survey in Hamilton. That study concentrated on locations where industrial and commercial

areas were close to residential areas. The "Hamilton Noise Survey"[10] contains the results of this Survey.

At the same time as the Hamilton survey, the Ministry sponsored a program at the University of Western Ontario to conduct community noise level measurements in London and Woodstock. The report of the study[11] summarizes noise levels at 75 locations in London and Woodstock and includes a sociological survey to assess the response of residents to neighbourhood environmental sound.

The City of Toronto,[12] Department of Public Works also sponsored a community noise study in 1972. Six hundred sites throughout the city were monitored and sociological responses surveyed.

A mathematical model to predict community noise levels from remote concentrated noise sources was developed by Thiessen[13] at the National Research Council of Canada. This model was used to calculate background levels for the City of Ottawa.

In order to obtain a more complete picture of environmental noise in Ontario, the present report adds the surveys of Kingston, North Bay and Sault Ste. Marie (population range 47,000 - 77,000) to the existing information. A further 105 locations distributed among eight different land-use zones were surveyed. Of special interest were those residential areas impacted by sound from other activity zones. Twenty-four hour monitoring was carried out at most sites on two weekdays, one Saturday and one Sunday. Traffic counts were also obtained over twenty-four hours at most major highways, and arterial roads adjacent to the sites.

The surveys were conducted with the help of five summer students working under S.W.E.E.P. (Student Working in Environmental Enhancement Program). One student was stationed in each of the three cities of Kingston, North Bay and Sault Ste. Marie to carry out measurements employing a total of six automatic noise monitors. The other two provided support

activities at the Noise Pollution Control Section office in Toronto. The program was designed and co-ordinated by an Acoustical Engineer of the Section and conducted in co-operation with the regional offices of the Ministry. Local city officials provided transport and helped the students to install the automatic noise monitors. Field measurements were performed from June to September 1973.

This report documents the community noise levels in the cities of Kingston, North Bay and Sault Ste. Marie and presents analysis of this data combined with similar information collected in the other Ontario surveys.

2. PURPOSE OF SOUND SURVEYS

Environmental sound surveys satisfy several important requirements:

(i) They provide for a better understanding of the existing sound environment and hence a background for the preparation of regulations.

(ii) When the data are analysed with reference to simultaneous sociological responses, criteria can be established for a desirable sound environment.

(iii) If a group of control sites is measured periodically, the long-term changes in community noise levels can, in some situations, be observed, thus providing a potential tool to assess the effectiveness of noise control legislation.

(iv) The data collected through surveys will prove useful in formulating guidelines of compatible land-use planning with respect to noise.

In addition to the above input into the regulatory process, the surveys add to the understanding of the relationships between the various statistical descriptors of the noise climate at a given site. It was with the above objectives that the surveys of Kingston, North Bay and Sault Ste. Marie were designed.

3. SITE SELECTION PROCEDURE

The rationale for the selection of communities, types of land use, measurement sites, etc., are briefly described in this section.

3.1 Selection of Communities

The cities selected for environmental sound level measurements were chosen to provide a representative cross-section of communities in Ontario

An extract from Industrial Surveys[14] conducted by the Ontario Ministry of Industry and Tourism is shown in Table 3.1. The data indicate industrial, commercial and residential activity in several Ontario cities.

The level of industrial activity in a community is indicated by the consumption of electric power and water, the proportion of people employed in manufacturing and the per capita average of industrial land use.

Similarly, the number of hotels, motels and retail establishments per capita indicate the level of commercial activity in a community; and the number of residential building permits, the number of hospital beds and the population characterise the level of institutional and residential activity of a community.

The communities previously surveyed by M.O.E., i.e. Hamilton, London and Woodstock are located in southern and western Ontario and have concentrations of industrial and manufacturing activity. The three cities surveyed here are of residential, institutional and commercial nature, located in eastern and northern Ontario.

3.1.1 North Bay: North Bay is located in northern Ontario. The large number of hotels and motels signify an active tourist industry; some diversified manufacturing industry is also present. The city is experiencing considerable growth of residential areas as signified by the number of building permits issued. This community can therefore be described as predominantly commercial and residential.

MUNICIPALITY	POPULATION AND % RISE BETWEEN 1966 and 1971	NO. EMPLOYED IN MANUFACTURING		POWER AND WATER CONSUMPTION		INDUSTRIAL LAND USAGE		INDUSTRY ALLOWED	MOTELS AND HOTELS		BUILDING PERMITS ISSUED		NO. OF BEDS IN HOSPITAL		NO. OF RETAIL ESTABLISHMENT		REMARKS
		TOTAL	NORMALISED PER 100,000 POPULATION	TOTAL	NORMALISED PER PERSON	TOTAL AVERAGE AND PRICE @ ACRE I - INDUSTRIAL M - MUNICIPAL P - PRIVATE	NORMALISED PER 100,000 POPULATION	L - LIGHT M - MEDIUM H - HEAVY	TOTAL NUMBER	NORMALISED PER 100,000 POPULATION	TOTAL NUMBER S - SINGLE FAMILY UNIT M - MULTIPLE FAMILY UNIT	NORMALISED PER 100,000 POPULATION	TOTAL NUMBER	NORMALISED PER 100,000 POPULATION	TOTAL NUMBER	NORMALISED PER 100,000 POPULATION	
Hamilton	302,000 +6.42%	76,000	25,200	672,000 KW 70,000,000 gln.	2.22 KW 232 gallons	I, 30, $15000	I-9.95	Yes, L,M,H	38	12.6	852-S. 2871-M.	S-282 M-950	7 Hospitals		4277	1417	Heavy Industry
Kingston	59,000 +8.81%	3,430	5,810	83,000 10,000,000	1.41 170	I, 52, $ 4000 M, 25, $ 3500 P, 390, —	I-88 M-42.4 P-660	Yes, L,M,H	39	66.0	17-S. 803-M.	S-28.8 M-1360	2342 beds	3980	500	848	Diversified industries emphasis on metal work and confectionary
London	220,000 +17.21%	23,000	10,450	248,000 22,000,000	1.13 100	I, 620,$ 9000 M, No P, 800,$10000	I-282.0 M-No P-364.0	Yes, L,M,H	61	27.5	1148-S. 221-M.	S-522.0 M-100.0	1600 beds	726	1570	714	
North Bay	47,000 +106%	2,000	4,260	18,000 4,500,000	0.383 95.7	I, 160,$ 6000 M, 26, P, 35, $ 5000	I-340.0 M-55.5 P-74.4	Yes, L,M,H	47	100	202-S. 94-M.	S-430 M-200	400 beds+ Psychiatric	850+	231	491	Diversified industries and tourist activity
Gloucester Town	37,000 +75%	800	2,160	27,000 300,000	0.73 81.0	I, — M, 86, $3500 P, 45, $15000	I- M-232 P-122	Yes, L,M,H	12	32.4	975-S. 597-M.	S-2640 M-1615	3000+beds (Ottawa)		60	162	Mainly residential
Nepean	64,000 +40%	3,200	5,000	42,330 6,200,000	0.66 97.0	I, No M, No P, 3000, $10000	I-No M-No P-4670	Yes, L,M,H	12	18.7	380-S. 1010-M.	S-594 M-1580	Ottawa Hospitals		—	—	Mainly residential
Ottawa	292,000 +1.26%	—	—	400,000 40,000,000	1.37 137	I, 45, $15000 M, 30, $ 9000 P, 100,$15000	I-15.4 M-10.3 P-34.2	Yes, L,M,H	53	18.2	N/A N/A	— —	3600 beds (Ottawa)		3000	1028	
Sarnia	56,200 +5.45%	7,130	12,700	65,000 10,700,000	1.16 191	I, 2500, — M, No P, 22 $15000	I-4,450 M, No P-39.2	Yes, L,M,H	6	10.7	129-S. 6-M.	S-230 M-10.7	648 beds	1152	215	383	Chemical industries
Sault Ste. Marie	77,400 +4.81%	12,680	16,400	77,000 8,000,000	0.995 103	I, 19, $ 7500 M, 25, $ 7200 P,100, $10000	I-24.5 M-32.3	Yes, L,M,H	39	50.4	492-S. 226-M.	S-635 M-292	600 beds	775	1105	1430	Industrial and residential activities
Sudbury	90,000 + 9.28%	25,614	28,500	100,000 8,500,000	1.11 94.5	I, 17, $28000 M, No P, 450,$ 8000	I-18.9 M-No P-500	Yes, L,M,H	39	43.2	442-S 173-M	S-491 M-192	809 beds	900	780	868	
Thunderbay	106,000 +8.16%	8,522	8,050	125,000 14,000,000	1.18 132	I, 100,$ 8500 M, 350,$ 3000 P, 970,$ 5000	I-94.3 M-330 P-914	Yes L,M,H	57	53.8	255-S 727-M	S-240 M-686	2244 beds	2120	700(1961)	660	Paper and pulp industries
Timmins	28,000 -3.4%	4,450	15,900	14,000 3,500,000	0.51 125	I, No M, Yes,$ 3500 P, No	I-No M-Yes P-No	Yes L,M,H	22	78.6	87-S 3-M	S-310 M-10.7	200 beds	714	N/A	—	Mining industires
Woodstock	25,100 +5.26%	7,320	29,200	34,600 3,700,000	1.38 147	I, No M, 173,$ 2100 P, 350,$ 2600	I-No M-690 P-1400	Yes, L,M,H	9	35.8	82-S 71-M	S-326 M-283	225 beds	900	216	860	

Table 3.1 : An Extract from Industrial Surveys - 1972, conducted by the Ontario Ministry of Industry and Tourism

3.1.2 Sault Ste. Marie: Sault Ste. Marie, also a northern city, has substantial industrial activity as well as a significant commercial and residential emphasis. This location, therefore, offers an opportunity to collect data in an industrial, commercial and, to some degree, residential environment.

3.1.3 Kingston: Kingston is located in eastern Ontario and has been described as an institutional city. A major university campus, a military college, a relatively large number of hospital beds and a penitentiary are located here. Large-scale growth of multiple family units has been planned and industrial activity is relatively modest. The community may be summarized as being mainly residential and institutional.

3.2 Selection of Measurement Sites

If a community had uniform sound levels, measurements taken at any one location would be representative of sound levels in the entire community. In actual practice, the levels are known to vary throughout a community depending on the land usage, population density and the location of noise sources.[15] These considerations, applied to the design of the present survey, are discussed in the sub-sections 3.2.1 and 3.2.2 below.

3.2.1 Land-Use Considerations: The sound levels measured at any site are a result of the activities prevailing in that area, usually identified by the municipal zoning in the vicinity of the site. Thus, the zoning can be employed in site selection to categorize different types of noise climates. The following land-use classifications were used in this study:

(i) Residential: Single-family detached and semi-detached homes, townhouses, rowhouses, trailer homes and low-rise and high-rise apartment buildings.

(ii) Commercial: Small neighbourhood shops, large shopping centres and commercial plazas, downtown commercial districts and automatic car washes.

(iii) Industrial: Vehicle Service and repair garages, machine shops, transformer stations, steel manufacturing, saw mills, metal fabrication and industrial plants.

(iv) Institutional: Schools, community colleges, universities, hospitals, group homes, churches, neighbourhood parks, playgrounds and stadiums.

When the two adjacent zones are clearly separated by a physical boundary, the sound environment of one zone may penetrate into the other. Such inter-zone intrusion of sound across the boundary is popularly known as sound spill-over and the affected areas as sound interfaces or mixed zones. Interfaces were of special interest in this study since a large percentage of the noise complaints in Ontario are received from these areas. The mixed zones of practical interest measured during the survey are listed below.

(v) Residential - Commercial

(vi) Residential - Industrial

(vii) Residential - Institutional

(viii) Residential - Commercial - Industrial

It is difficult to define mixed land-use zones in terms of the distance overlap of the individual zones, because among other factors it also depends on the type and the extent of activities in the constituent zones, the size of the zones, and the nature of their common boundaries and the presence of any structures at the interface. As a guideline, the maximum limit of overlap is considered to be 600' for the present study.

3.2.2 Criteria for Selecting Individual Sites: Individual sites in an area can be selected either randomly or deterministically. In the random method a grid of one-half or one mile size is superimposed on the map of a city and the locations at the intersection of grid lines are selected. When a statistical description of the noise climate in an individual community is required the random method is employed. One requirement of this approach is that a fine grid size is recommended to adequately represent the major and fixed noise sources.

This requirement is not necessary in the deterministic approach which assumes a prior knowledge of the major noise sources and the sound characteristics of the city. The approach is suited to analyse a wide range of noise situations present in a community by including all the regular as well as unique sources.

Since the purpose of the survey was to collect sound samples from a number of communities with different types of sound characteristics rather than to evaluate the statistical levels of individual cities, the deterministic approach was applied. Local noise sources of interest and areas of noise complaint activity were also reviewed with city planning officials and local representatives of the Ministry of the Environment prior to designing the surveys.

The monitored sites satisifed the following conditions:

(i) The noise climate at the site was not dominated by a minor noise source, such as, a residential air-conditioner or a small exhaust fan. Measurement locations situated in the immediate neighbourhood of the major transportation corridors (freeways, railway routes and aircraft flight paths) were avoided in this survey. Also, excluded from this survey were the areas where intensive construction activity prevailed.

(ii) The site was free from any reverberation effects due to the presence of tall reflecting surfaces and confined spaces.

(iii) The monitoring site was not located in an immediate vicinity of stop-lights, since any coincidence between the cycle of lights and the sound sampling rate would bias the measurements.

Levels reported here were recorded with automatic noise monitors installed on public-utility poles, which were usually located within a few feet from the curb or the edge of the pavement.

4. MEASUREMENT AND ANALYSIS PROCEDURE

4.1 Period of Sound Measurement

Since the levels in a community may vary considerably with the time of the day, the site measurements were performed over a 24 hour period and later analysed for the three sub-periods of daytime (7:00-19:00 hours), evening (19:00-23:00 hours) and night-time (23:00-7:00 hours). Although the choice of these hours is somewhat arbitrary, the three sub-periods represent changes in daily activity patterns in the community.

4.2 Sound Sampling Technique

Ideally, community noise levels should be recorded continuously for a 24 hour period, to monitor all intrusive sounds present at a site. But, the high cost required for instrumentation makes such monitoring impracticable. As an alternative, environmental sound sampling methods of frequently recording short duration samples are now being widely used.[9,10,11,12,16] However, the inherent limitation of the sampling method has to be recognised. If the samples recorded are not sufficiently long and frequent enough, some of the noise events occurring at a site will not be recorded. A pilot study was undertaken to quantitatively establish an acceptable sampling rate for this survey. The continuous and the intermittent (at least 40 seconds of continuous sound samples every 20 minutes) recordings measured over a 24 hour period were compared for a single-family residential area exposed to local traffic, and for a commercial downtown location in London.[11] The absolute difference between the levels obtained by the two methods is presented as the sampling error in Table 4.1. The maximum error in determination of L_{10} for the three sub-periods is 3 dBA diminishing to 2 dBA for L_{90}. The corresponding figures for L_{max} and $L_{2.5}$ are 10 and 9 dBA, respectively. The sampling rate was considered adequate to measure L_{10}, L_{50} and L_{90}, since in these cases the errors were compatible with the overall accuracy of the instrumentation. By employing a more frequent sampling rate, a considerable reduction of sampling errors in the estimation of L_{max}, $L_{2.5}$ and other high-level intrusion descriptors is obtained, and a slight improvement in the measurement accuracy of L_{10}, L_{50} and L_{90} can be expected.

Location and Period	L_{max}, dBA	*$L_{2.5}$, dBA	L_{10}, dBA	L_{50}, dBA	L_{90}, dBA
Downtown Commercial:					
daytime (7:00-19:00 hrs.)	10	3	1	1	0
evening (19:00-23:00 hrs.)	10	9	2	2	2
night-time (23:00-7:00 hrs.)	4	3	2	2	1
Single Family Residential:					
daytime (7:00-19:00 hrs.)	4	4	2	1	0
evening (19:00-23:00 hrs.)	6	1	1	1	1
night-time (23:00-7:00 hrs.)	8	5	3	1	0

* $L_{2.5}$ is sound level exceeded 2.5% of the time during the measurement period.

Table 4.1: Error in Determination of L_{max}, $L_{2.5}$, L_{10}, L_{50} and L_{90} due to the Intermittent Sampling Rate of 40 seconds every 20 minutes.[11]

In view of this observation, the automatic noise monitors were adjusted to sample 10 seconds every 5 minutes in Kingston, North Bay and Sault Ste. Marie. The data reported in the literature also supports the choice of this sampling rate.[16] The sampling rates used in the various community noise surveys are summarised in Table 4.2.

4.3 Data Retrieval and Processing of Tapes

After the 24 hour recordings were successfully completed, the tapes were spot-checked to ensure against prolonged segments of wind noise or any unusual sounds. A check of daily weather conditions also helped to ensure the quality of recordings. Tapes prepared during rainy or excessively windy conditions were discarded and monitorings repeated on the appropriate days and sites. All tapes were coded and catalogued prior to the processing.

Tapes were processed using the computer system employed for the London and Woodstock[11] recordings, with only one difference. To monitor each sample in the London and Woodstock survey the tape recorder was switched on and off once. This produced a pair of run-up and run-down transients on the tape, as a part of the 40-plus second recording. To eliminate these transients in later analysis, a D.C. cue signal was manually inserted at the beginning of each sample. subsequently, during the computer processing, everytime the cue signal was detected, 40 seconds of sample was digitized from the 40-plus second sample. With the shorter 10 second samples being recorded in the present survey, however, the accuracy of the manual insertion of the cue signal was less reliable. Cost and time considerations precluded the development of an automatic signal inserter device. Consequently, the transients were included as a part of the noise climate in the final analysis. The shape of these transients, however, is such that this error is much smaller compared to the estimates shown in Table 4.1.

To summarize the steps involved in data-processing of tapes, the analog data from the field tapes were digitized at one-half second intervals; the digital data was then aggregated using a 1 dBA window to compute the statistical descriptors. A PDP 8 computer program originally employed in the London and Woodstock data analysis was expanded to include calculations of L_{eq}, L_{NP}, TNI and standard deviation.

All of the field tapes prepared during the community noise monitoring are retained by the Noise Pollution Control Section for future reference and for any further analysis.

Name of Survey	Sound Sampling Rate	Measurement Mode
Kingston, North Bay and Sault Ste. Marie	10 seconds every 5 minutes	Automatic Recording
London and Woodstock[11]	longer than 40 seconds every 20 minutes	Automatic Recording
Hamilton[10]	35 seconds every 15 minutes	Automatic Recording
Toronto[12]	40 seconds every 20 minutes	Automatic Recording
Edmonton[9]	15 seconds every 4 minutes	Automatic Recording
Greater Vancouver[8]	Observing needle of sound level meter for 15 seconds 10 times at each site.	Visual observation of sound level meter
Tokyo[7]	50 times at intervals of 5 seconds	Visual observation of sound level meter

Table 4.2: Summary of Environmental Sound Sampling Rates Used in Various Community Noise Surveys

4.4 Sound Level Presentation

The typical computer print-outs obtained from the analysis of a 24 hour tape are presented in Figures 4-1 and 4-2. The code 8MF6 printed at the top of the graphs signifies the location (site 8), the measurement day (Monday), a summary of the prevailing weather conditions (fair) and the noise recorder employed (no. 6), respectively.

Figure 4-1 shows the hourly variation of L_{max}, L_1, L_{10}, L_{50} and L_{90} over a 24 hour measurement period. Although the monitoring of sites always began at 9:00 hours, because of a preferred format of presentation the data on the graph is arranged to start at midnight; thus the left portion of the curves between midnight to 9:00 hours represents early morning levels of the following day, in this case Tuesday.

The graph of L_{max} (represented by A) represents the maximum levels measured for each hour; the ambient levels are given by the plot of L_{90} (represented by E). The variations of other statistical descriptors fall within the range defined by these two curves. The higher daytime levels correspond to the increase in activity during the day, whereas the lower night-time levels reflect a reduction in community activity. Heavy vehicular traffic activity and rush-hour community activity are represented by the peaks of the curves.

Figure 4-2 is the graph of a cumulative distribution of sound levels over daytime, evening, night-time and the 24 hour periods at the site. From this graph, the corresponding L_{max}, L_1, L_{10}, L_{50} and L_{90} may be derived. As shown, the values of statistical descriptors are the lowest for the night-time distribution, and highest for daytime and evening measurements.

Similar computer print-outs of all the processed tapes are listed in the appendices to this report together with the physical descriptions of sites, a table summary of statistical levels, and meteorological and traffic data. Appendices I, II and III are devoted to Kingston, North Bay and Sault Ste. Marie, respectively. The measurement locations are shown on the city maps presented at the end of this volume.

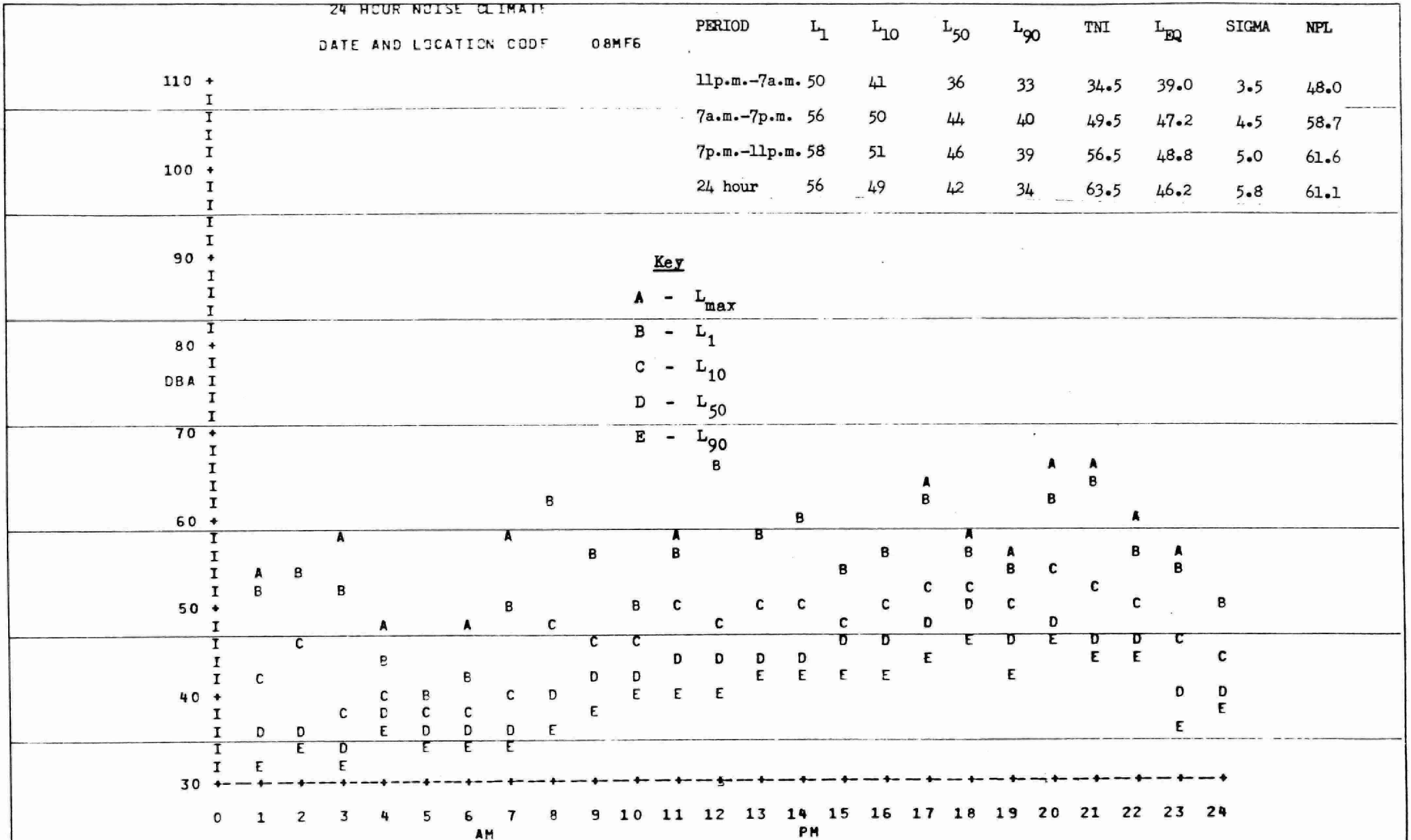

Figure 4-1 : A Typical Noise Climate Distribution Graph

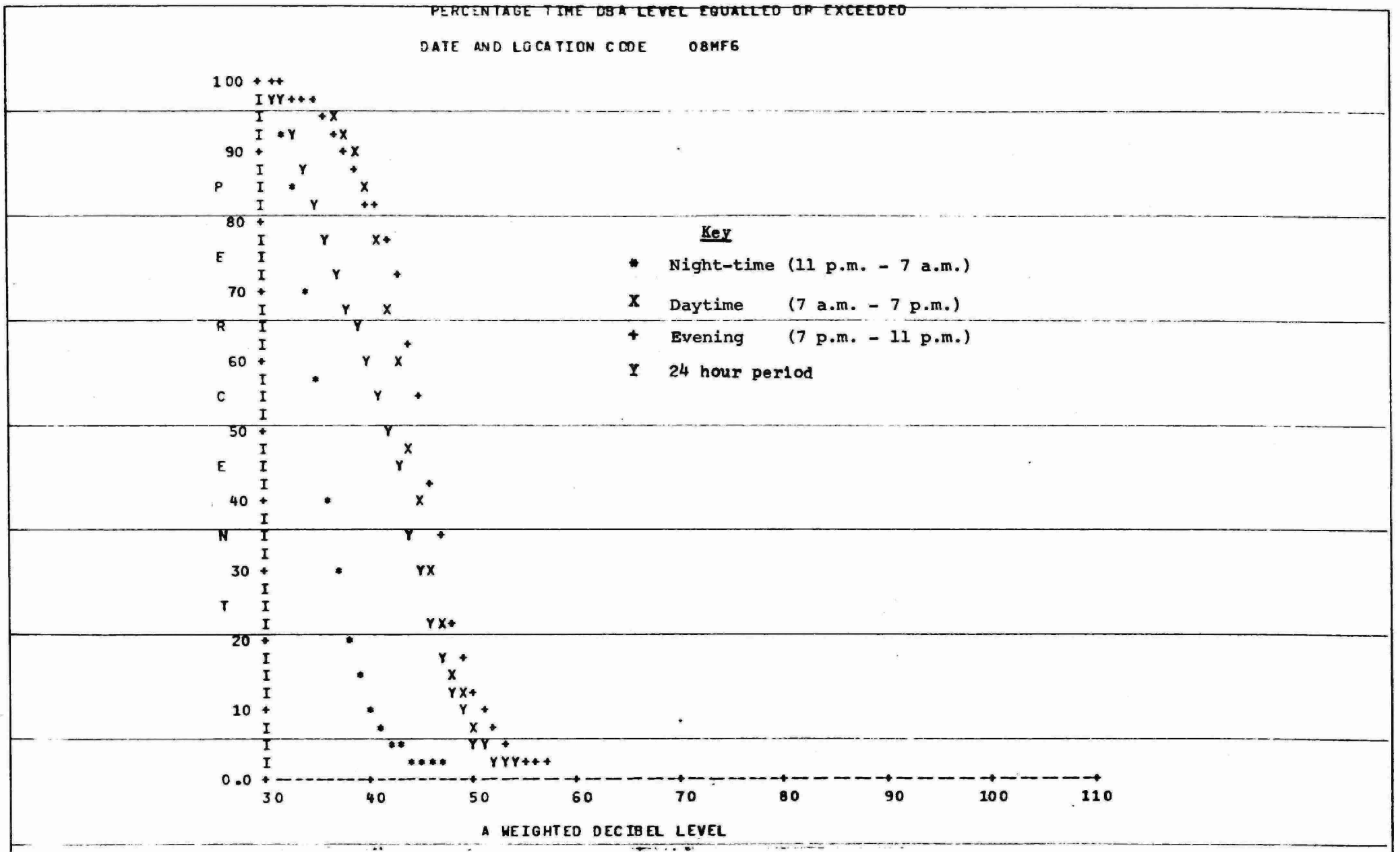

Figure 4-2 : A Typical Cumulative Distribution Graph

5. RESULTS

Kingston, North Bay and Sault Ste. Marie data were analysed with the corresponding information obtained in London and Woodstock, to observe the province-wide characteristics of community noise. Unfortunately, L_{eq} levels for all the land uses, and the statistical levels at commercial, institutional, industrial and residential-commercial-industrial sites could not be included in this analysis, since they were not obtained in the London and Woodstock Study.

Two sets of weekday data were formed for initial analysis. The first set included the levels obtained during one of the two weekdays monitored in Kingston, North Bay and Sault Ste. Marie, and the summer-time data of London and Woodstock. The second set consisted of the other weekday measurements in Kingston, North Bay and Sault Ste. Marie, and the winter-time data of London and Woodstock. For those sites monitored for only one weekday, the levels were included in both the sets of weekday data.

Histograms showing the distribution of measured sound levels at monitored sites, were obtained for each land-use category. L_{90}, L_{10} and L_{eq} histograms are presented in Figures 5.1 to 5.24, 5.25 to 5.48 and 5.49 to 5.72, respectively, for one of the two sets of weekday data.

Arithmetic averages of the daytime measured levels were determined for all sites in each of the eight land-use zones. In the same manner, night-time and evening averages were also obtained. The mean levels so computed are summarized in Tables 5.1 to 5.3. Standard deviations, the number of sites and 95% confidence limits for the means are also listed for the two sets of weekday data (marked Set 1 and 2).

Combined histograms of all sites measured in residential, residential-institutional, residential-commercial and residential-industrial zones are shown in Figures 5.73 to 5.84. From these histograms, L_{90}, L_{50}, L_{10} and L_{eq} levels prevailing at various percentiles of residential sites were computed, as reported in Table 5.4. To illustrate an application of such information, the cumulative graph of Figure 5.85 shows what percentage of residential sites in Ontario communities are exposed to different L_{90} and L_{eq} levels.

To observe the day-to day variation of levels at sites, L_{90} and L_{10} levels of residential and residential-commercial zones are listed in Table 5.5 for each of the two weekdays, Saturday and Sunday.

Toronto levels are compared against those of other Ontario communities in Table 5.6. Daytime data were not included in this comparison, because of a different definition of daytime (6:00 to 24:00 hours) used in Toronto Survey[12].

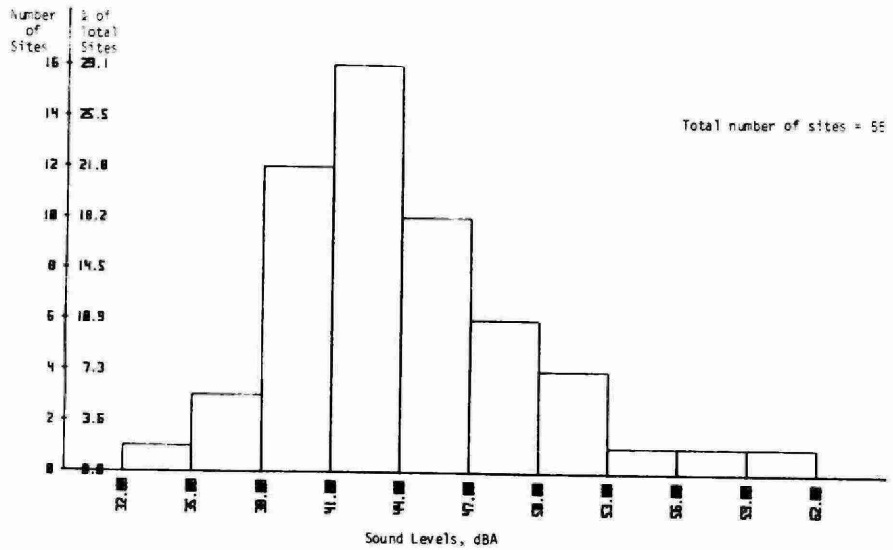

Figure 5.3 Night-time L_{90} Sound Levels in Residential Zones

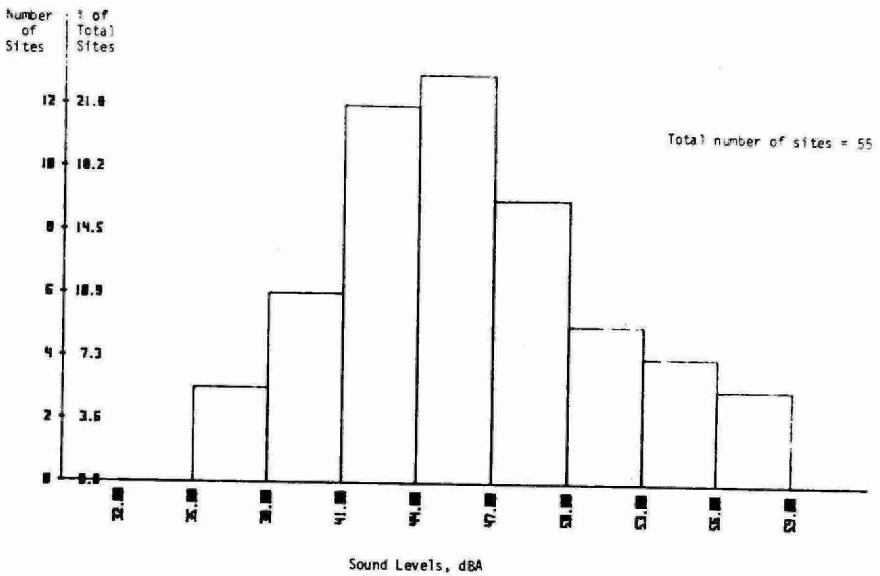

Figure 5.2 Evening L_{90} Sound Levels in Residential Zones

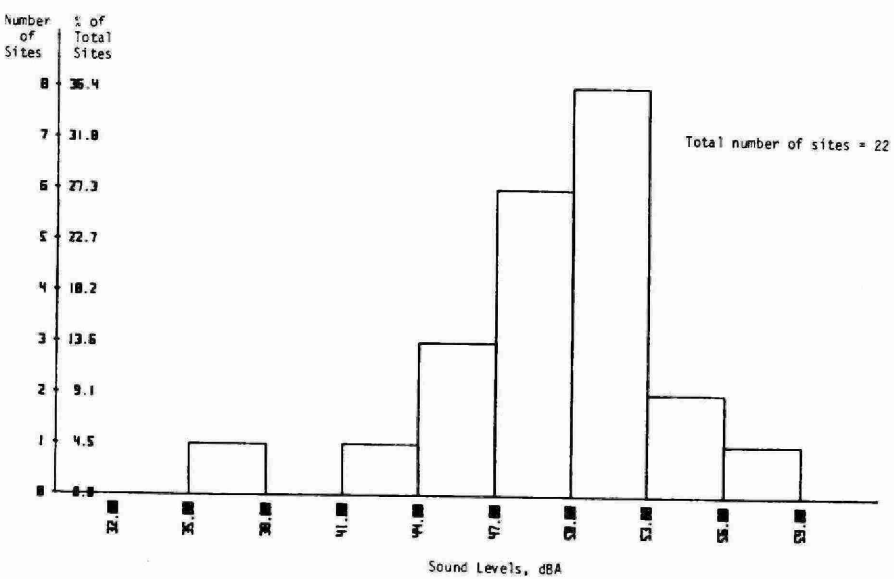

Figure 5.4 Daytime L_{90} Sound Levels in Residential-Institutional Zones

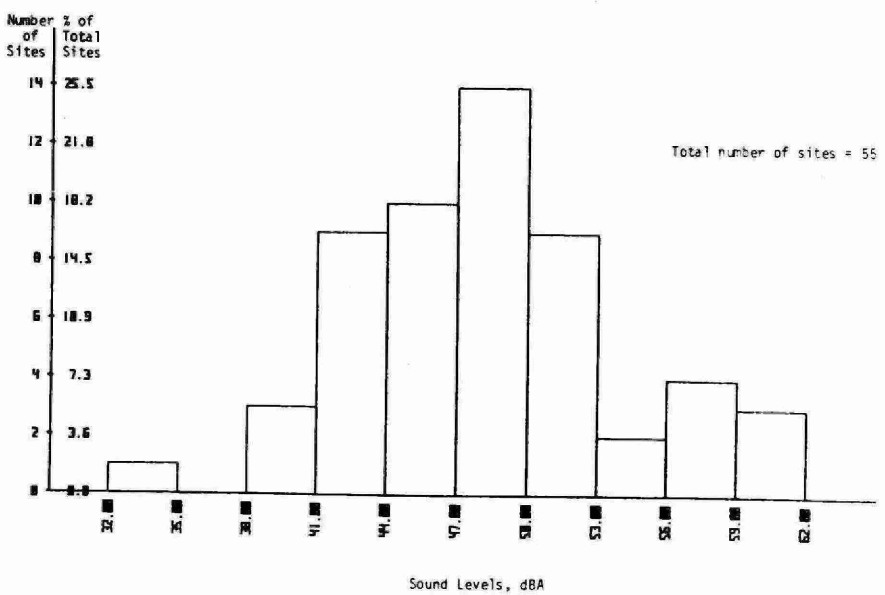

Figure 5.1 Daytime L_{90} Sound Levels in Residential Zones

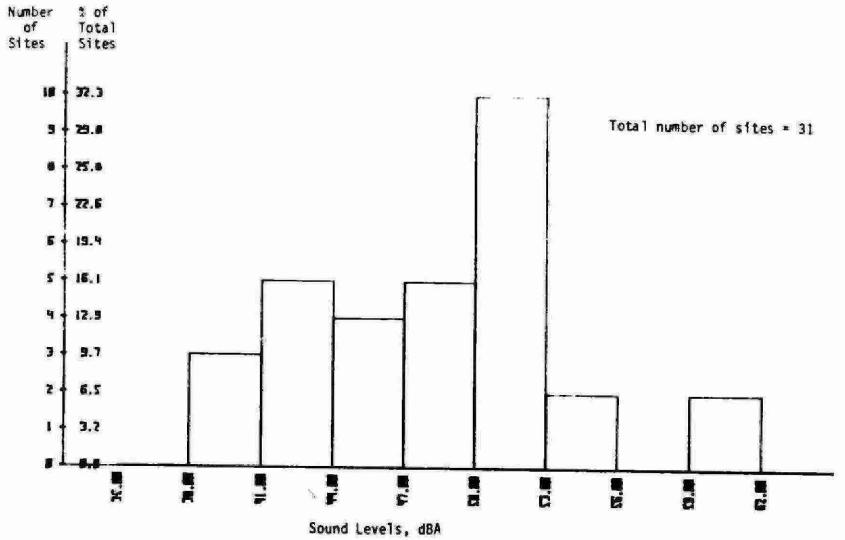

Figure 5.7 Daytime L_{90} Sound Levels in Residential-Industrial Zones

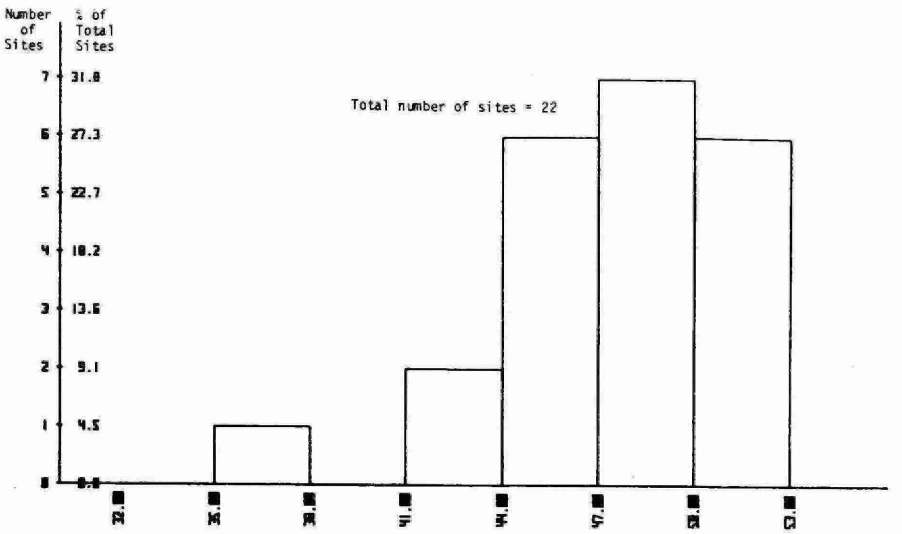

Figure 5.5 Evening L_{90} Sound Levels in Residential-Institutional Zones

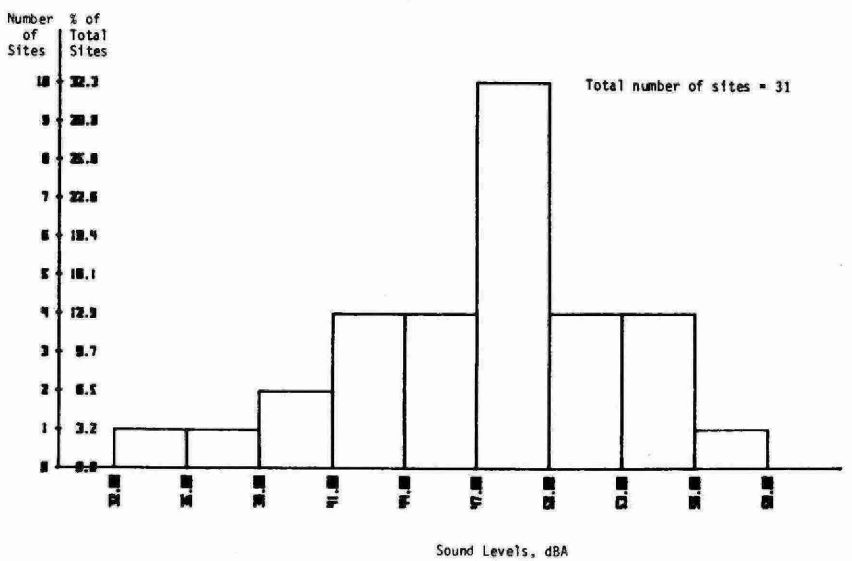

Figure 5.8 Evening L_{90} Sound Levels in REsidential-Industrial Zones

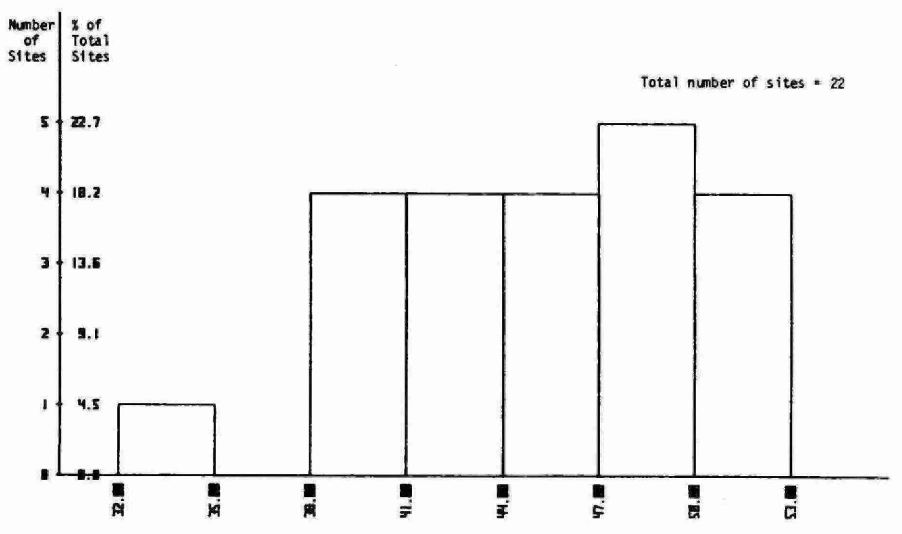

Figure 5.6 Night-time L_{90} Sound Levels in Residential-Institutional Zones

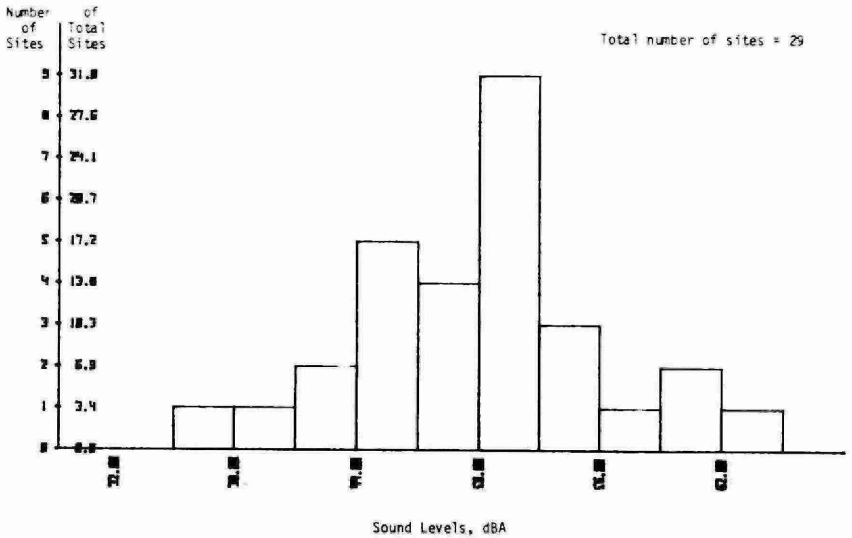

Figure 5.11 Evening L_{90} Sound Levels in Residential-Commercial Zones

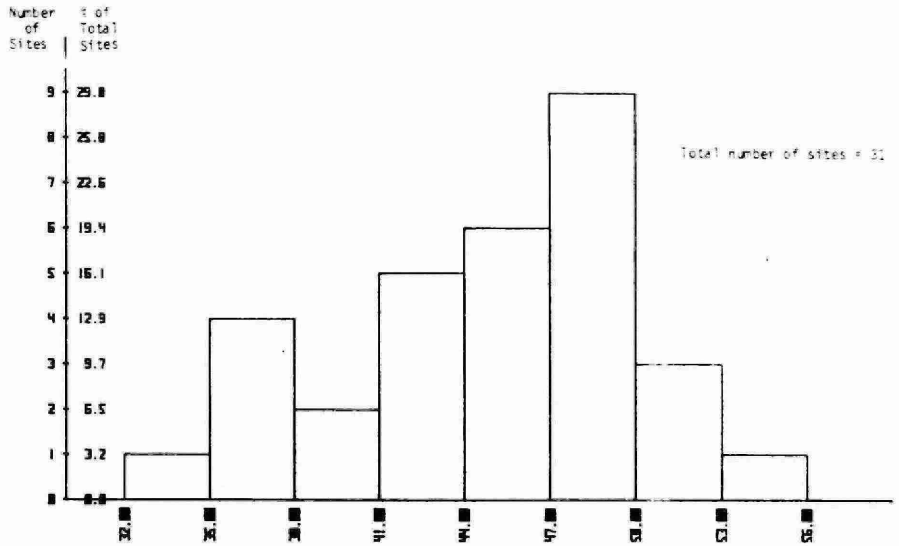

Figure 5.9 Night-time L_{90} Sound Levels in Residential-Industrial Zones

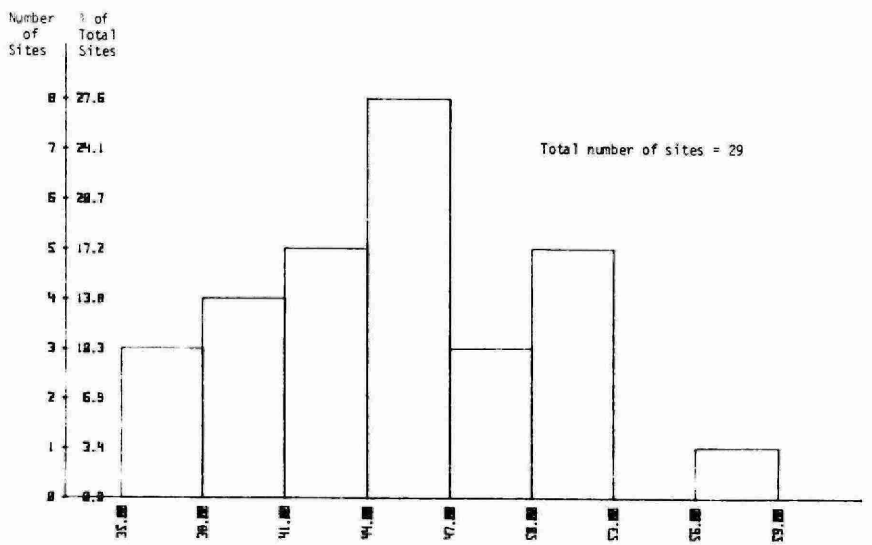

Figure 5.12 Night-time L_{90} Sound Levels in Residential-Commercial Zones.

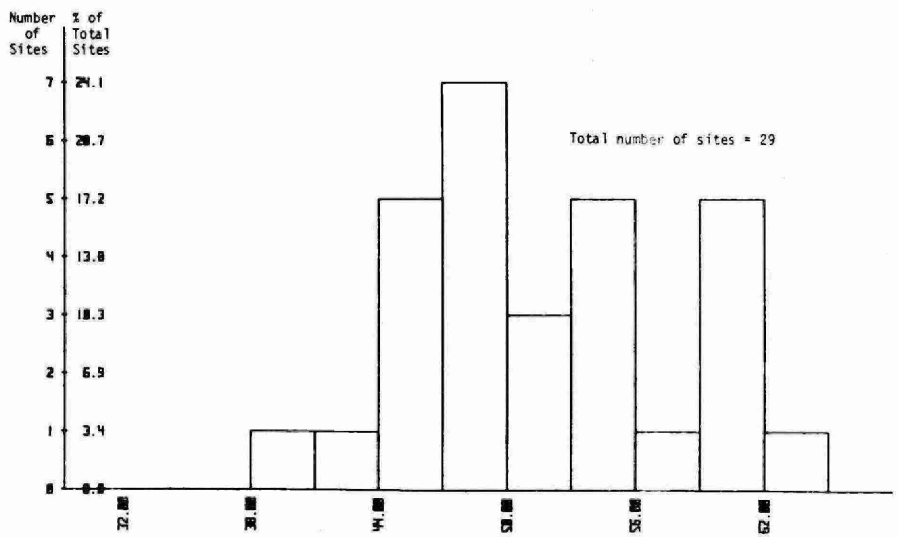

Figure 5.10 Daytime L_{90} Sound Levels in Residential-Commercial Zones.

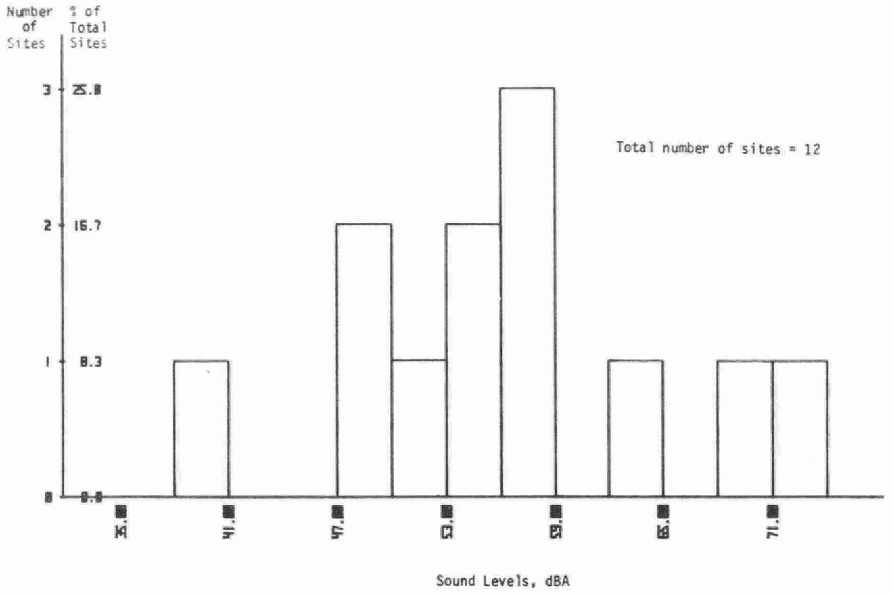

Figure 5.15 Night-time L_{90} Sound Levels in Industrial Zones

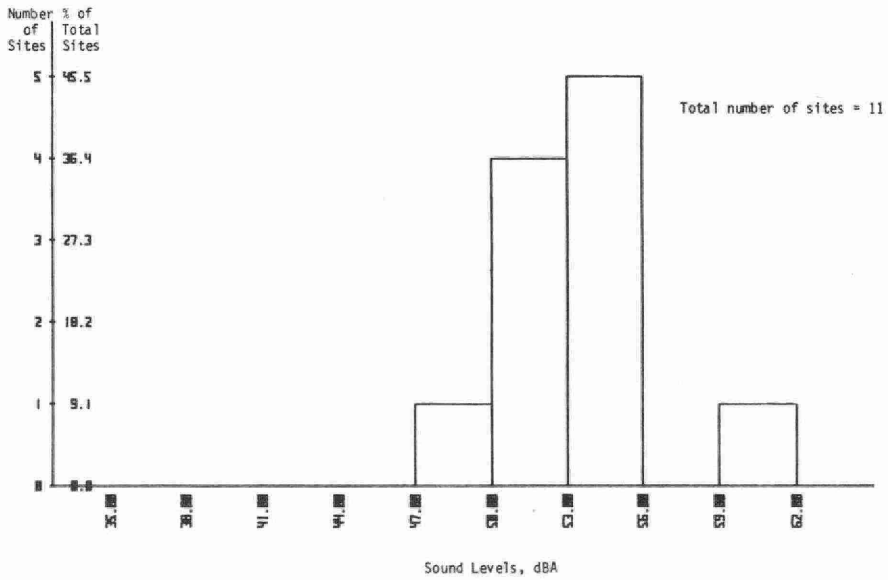

Figure 5.16 Daytime L_{90} Sound Levels in Commercial Zones

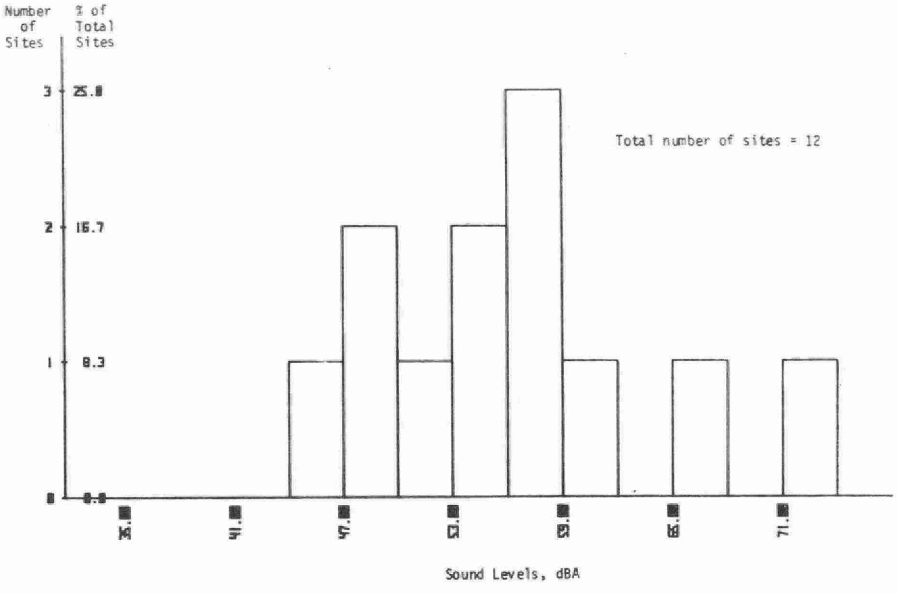

Figure 5.13 Daytime L_{90} Sound Levels in Industrial Zones

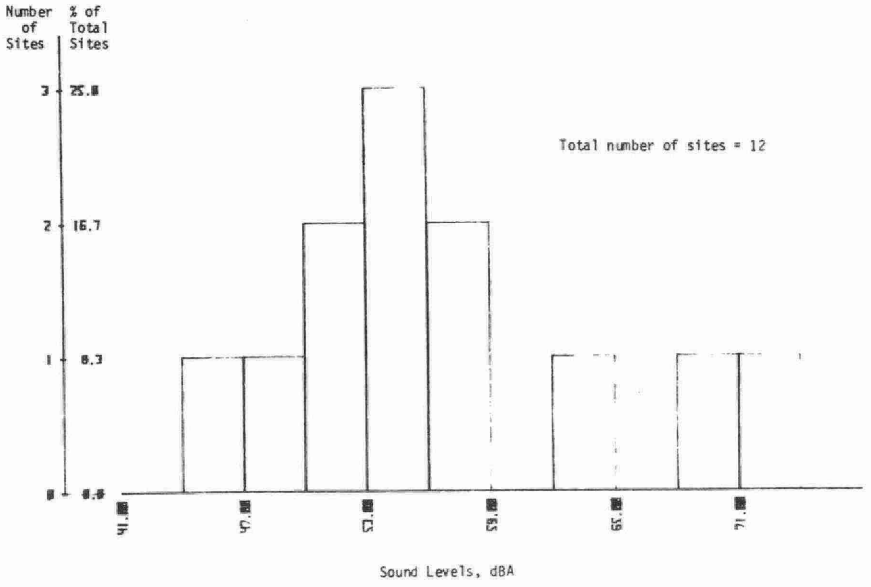

Figure 5.14 Evening L_{90} Sound Levels in Industrial Zones

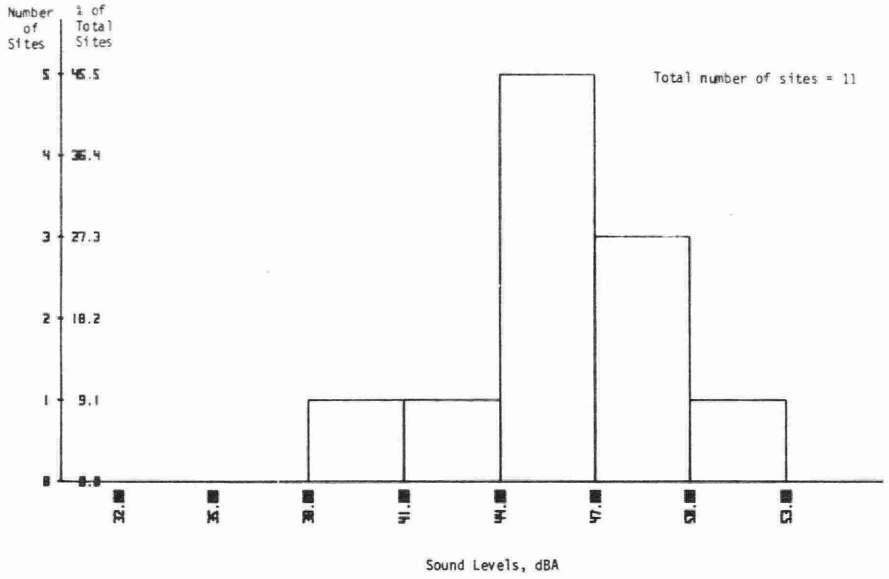

Figure 5.19 Daytime L_{90} Sound Levels in Institutional Zones

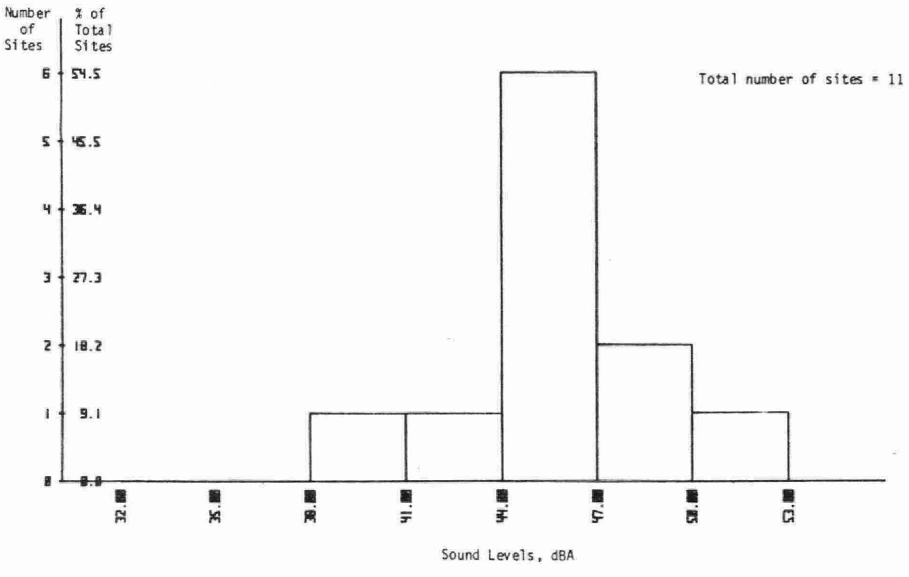

Figure 5.20 Evening L_{90} Sound Levels in Institutional Zones

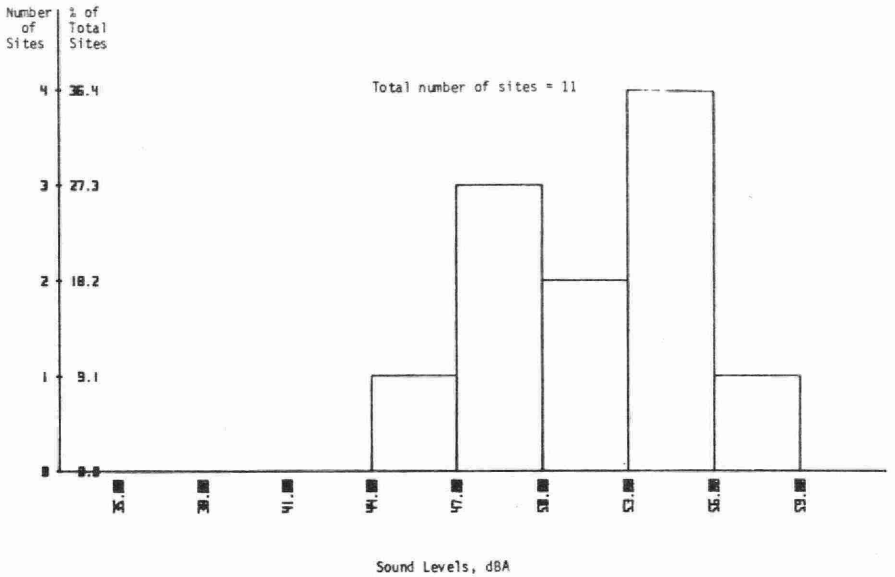

Figure 5.17 Evening L_{90} Sound Levels in Commercial Zones

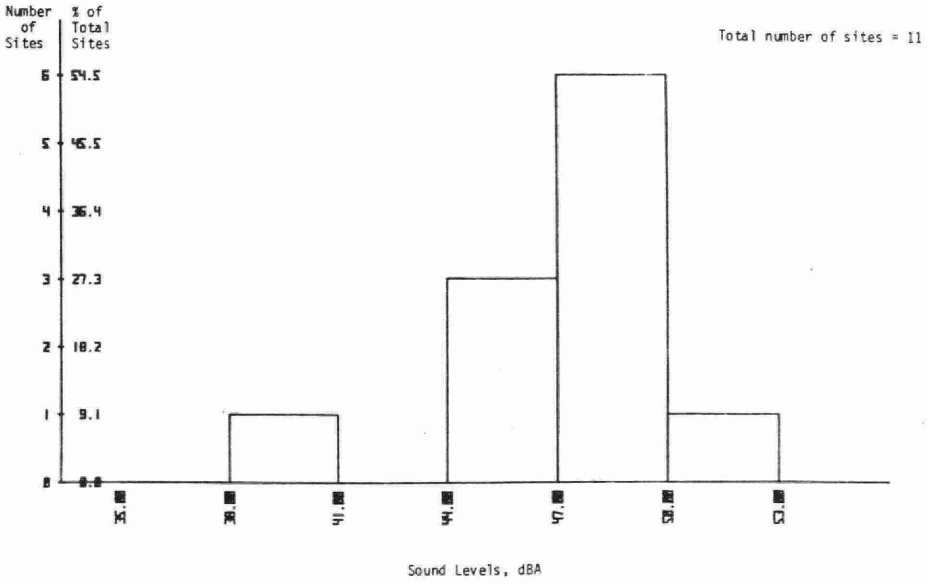

Figure 5.18 Night-time L_{90} Sound Levels in Commercial Zones

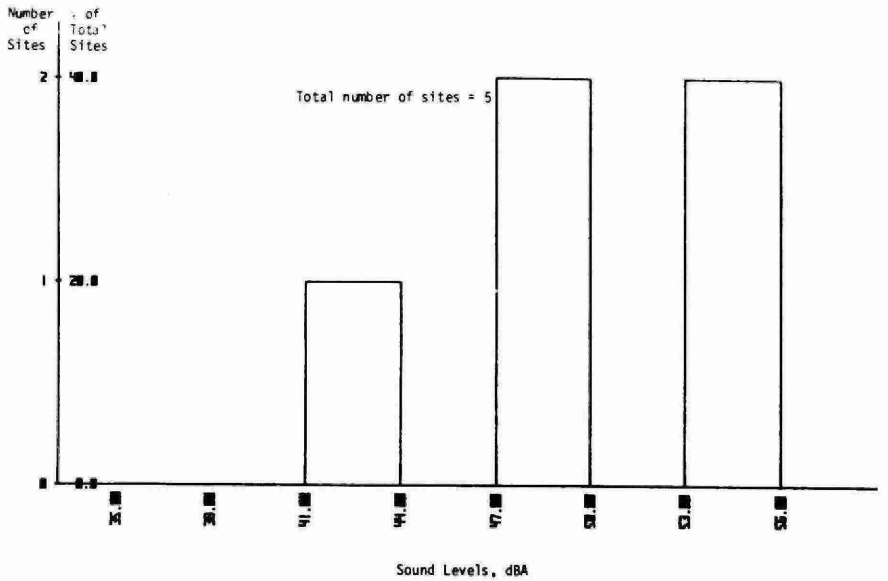

Figure 5.23 Evening L_{90} Sound Levels in Residential-Commercial-Industrial Zones

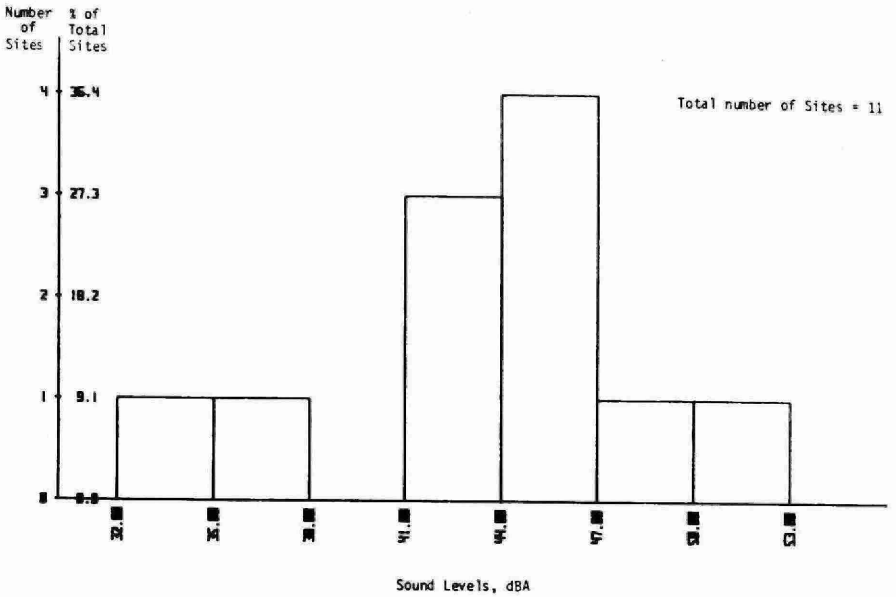

Figure 5.21 Night-time L_{90} Sound Levels in Institutional Zones

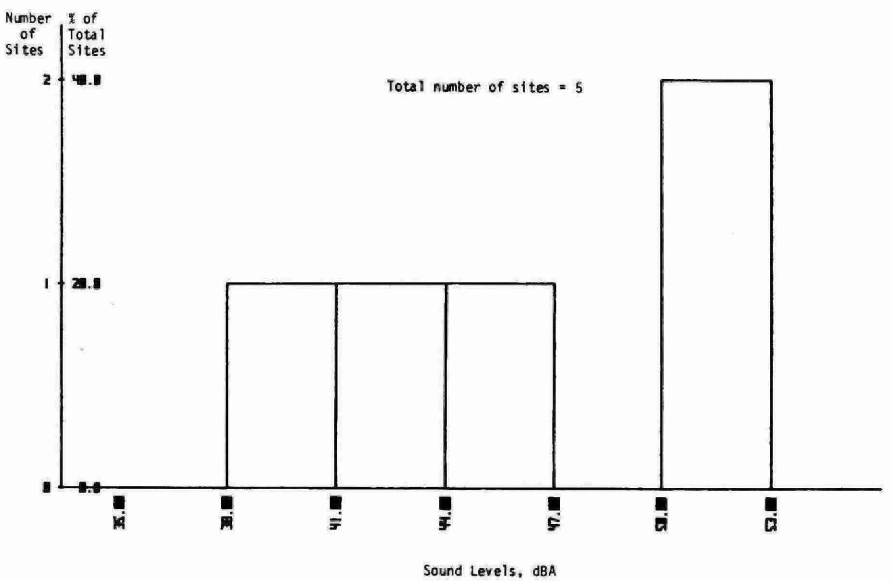

Figure 5.24 Night-time L_{90} Sound Levels in Residential-Commercial-Industrial Zones

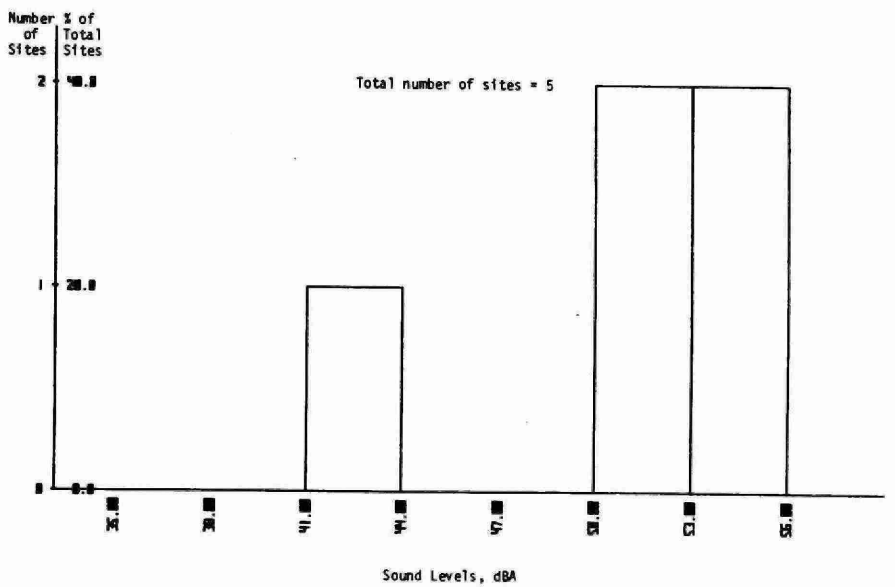

Figure 5.22 Daytime L_{90} Sound Levels in Residential-Commercial- Industrial Zones

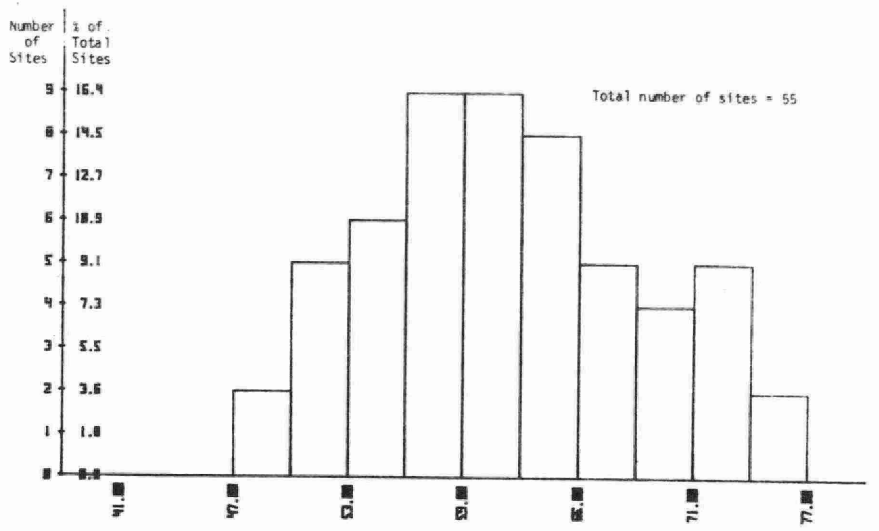

Figure 5.25 Daytime L_{10} Sound Levels in Residential Zones

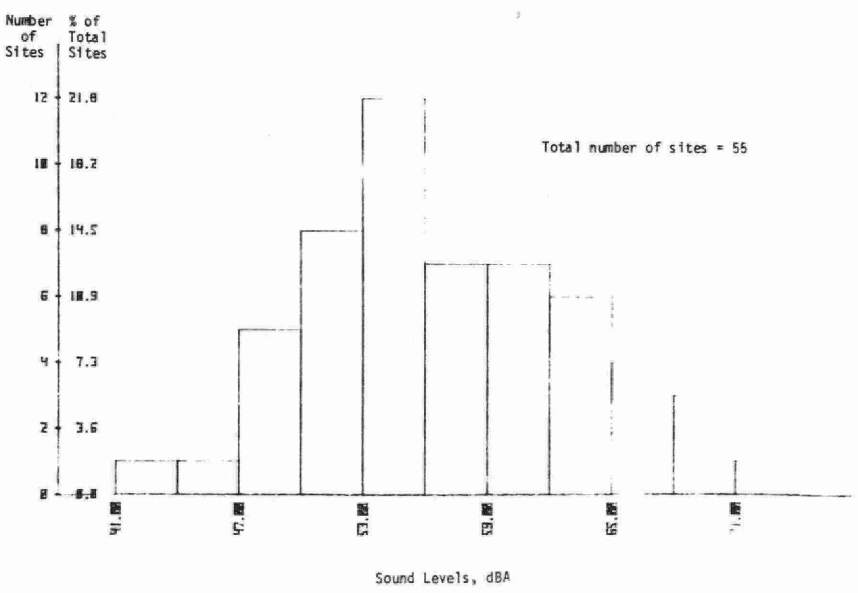

Figure 5.26 Evening L_{10} Sound Levels in Residential Zones

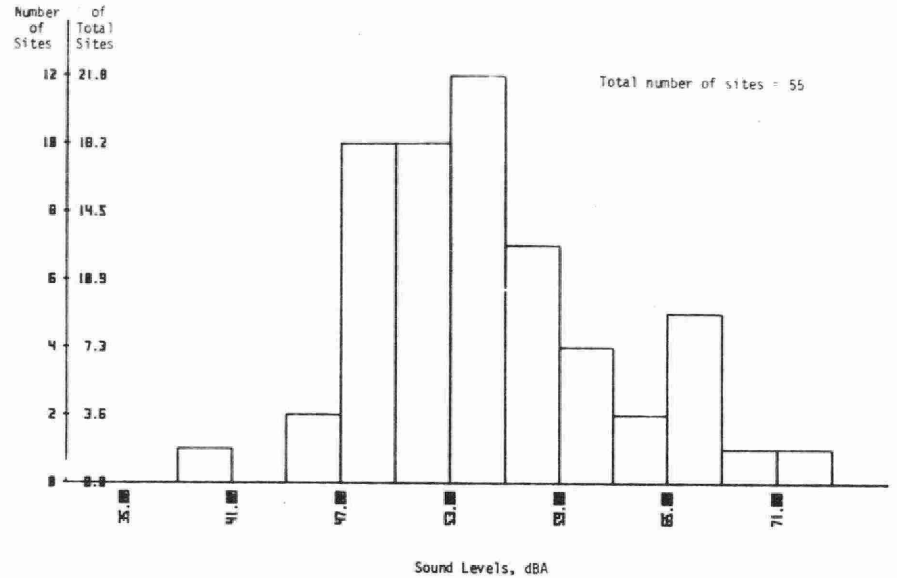

Figure 5.27 Night-time L_{10} Sound Levels in Residential Zones

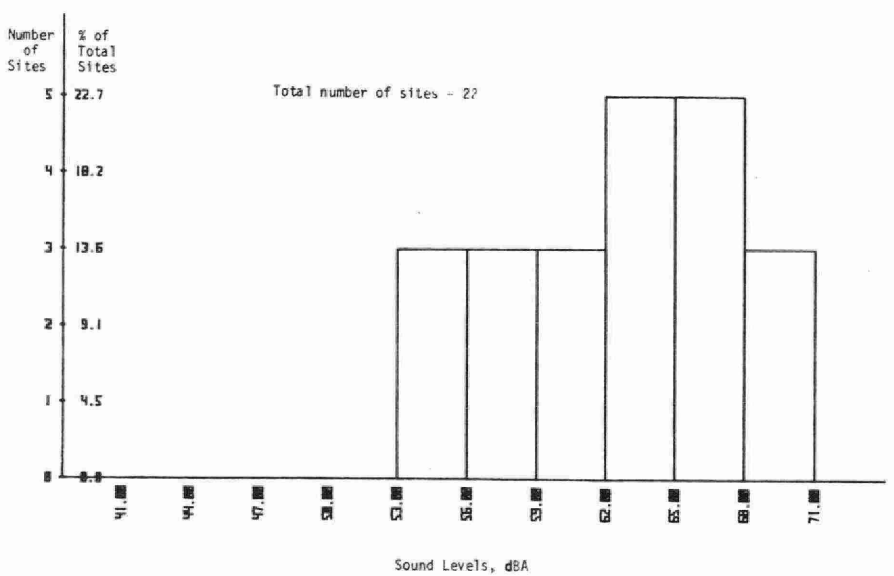

Figure 5.28 Daytime L_{10} Sound Levels in Residential-Institutional Zones

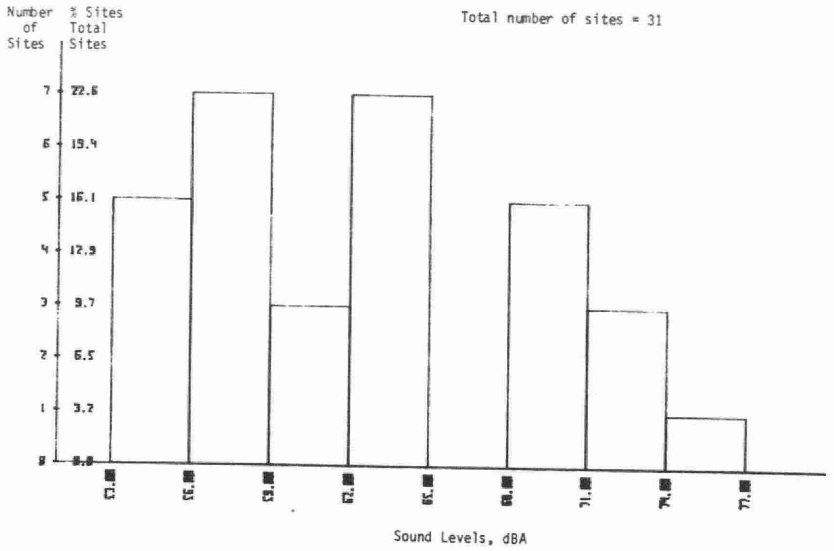

Figure 5.31 Daytime L_{10} Sound Levels in Residential-Industrial Zones

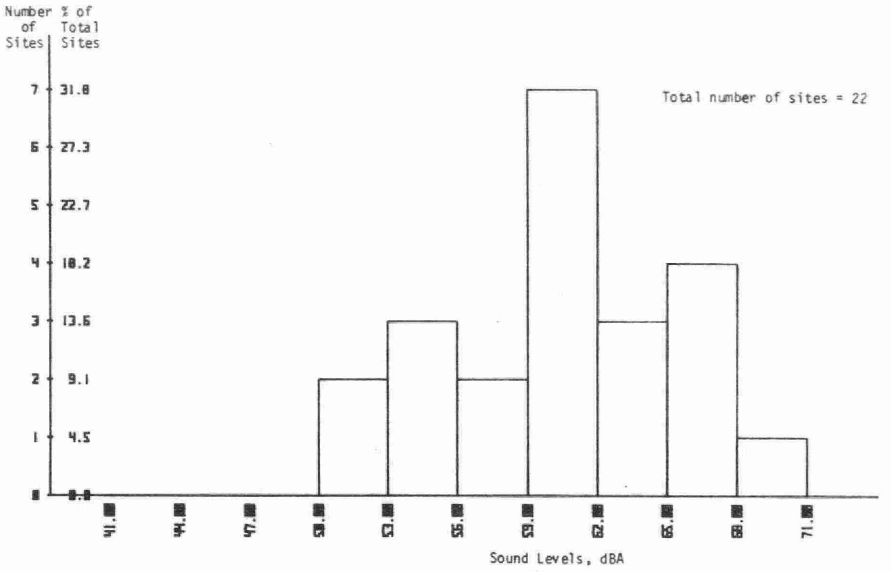

Figure 5.29 Evening L_{10} Sound Levels in Residential-Institutional Zones

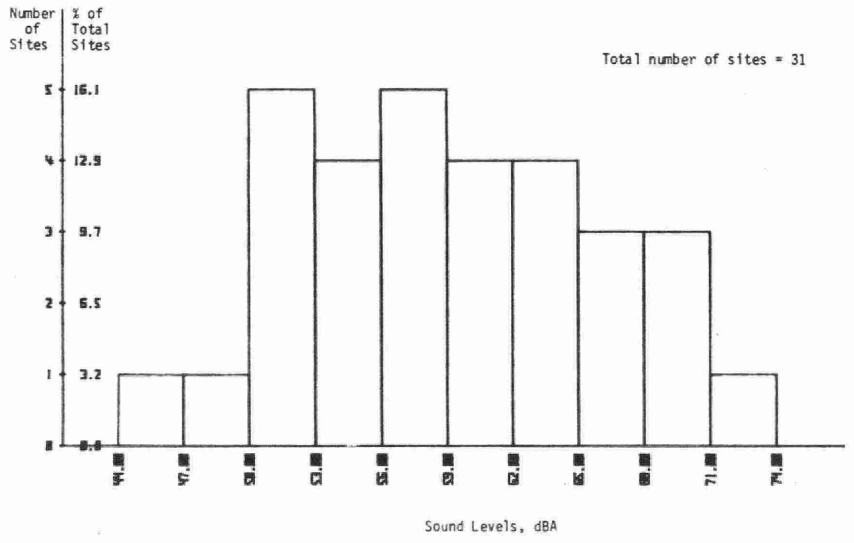

Figure 5.32 Evening L_{10} Sound Levels in Residential-Industrial Zones

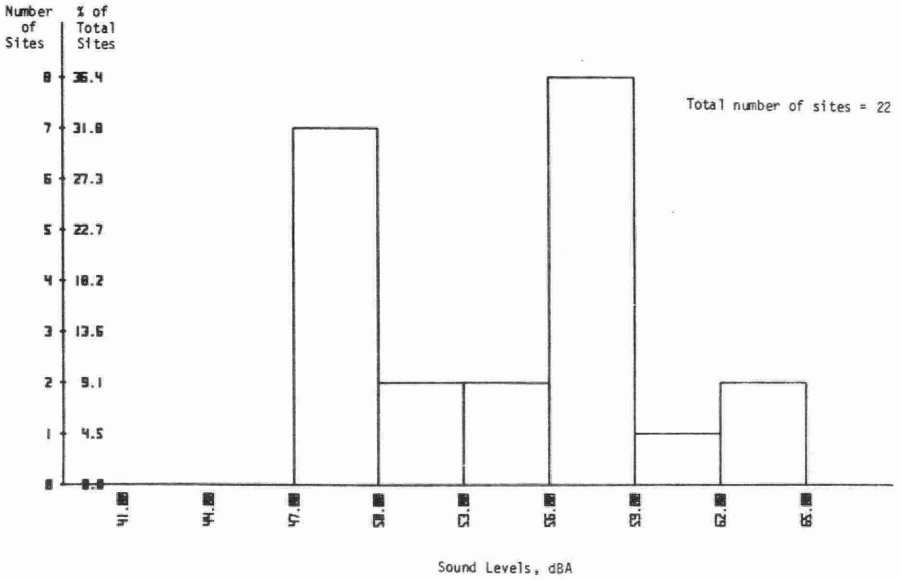

Figure 5.30 Night-time L_{10} Sound Levels in Residential-Institutional Zones

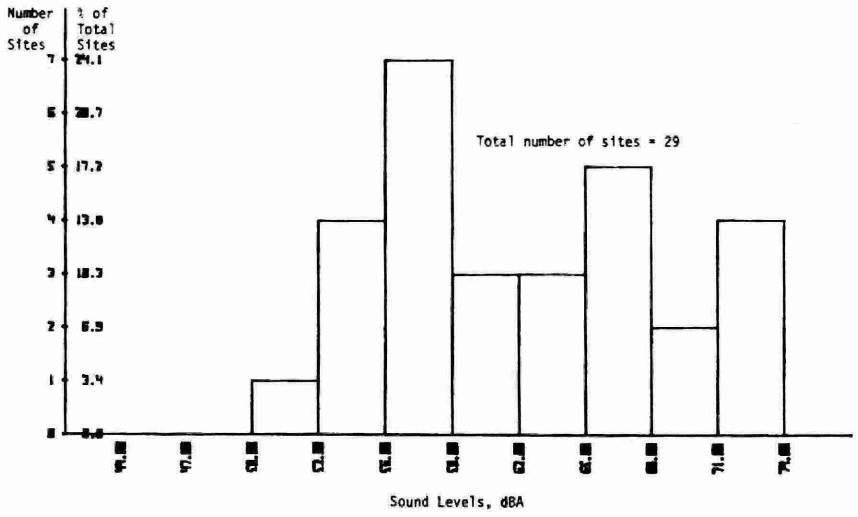

Figure 5.35 Evening L_{10} Sound Levels in Residential-Commercial Zones

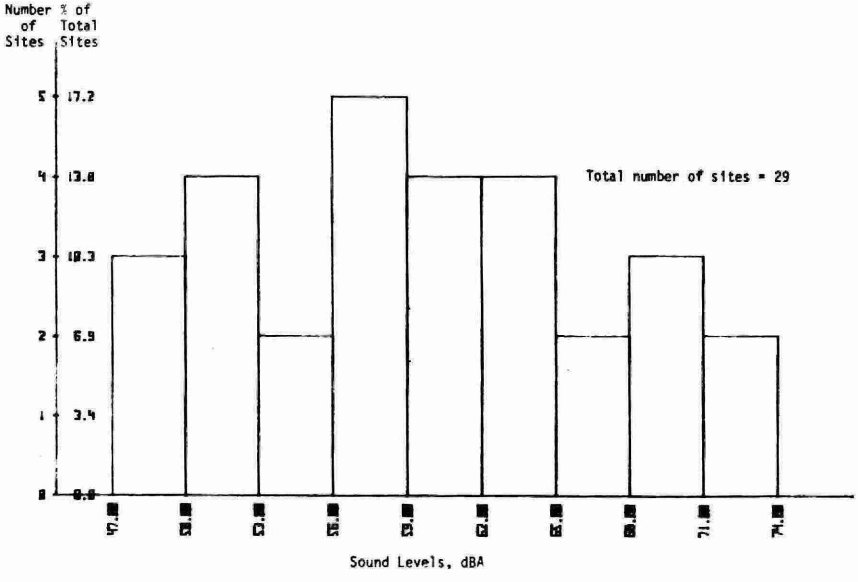

Figure 5.36 Night-time L_{10} Sound Levels in Residential-Commercial Zones

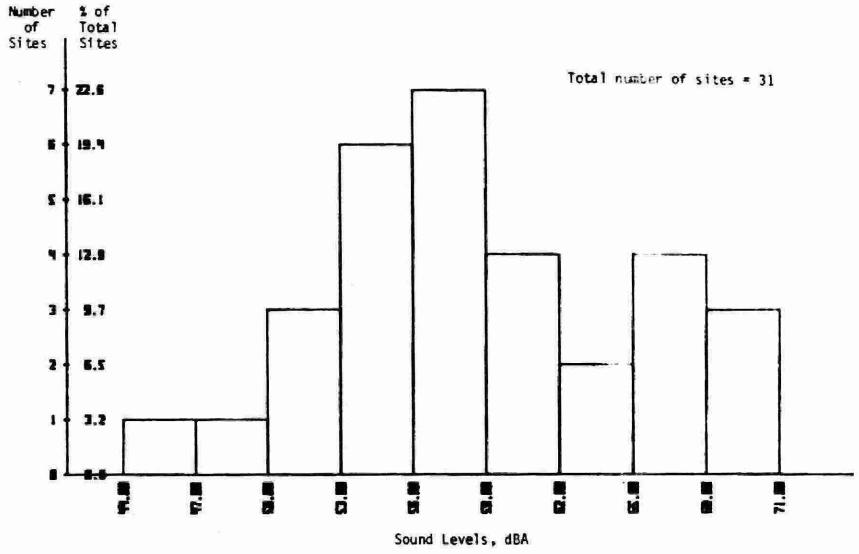

Figure 5.33 Night-time L_{10} Sound Levels in Residential-Industrial Zones

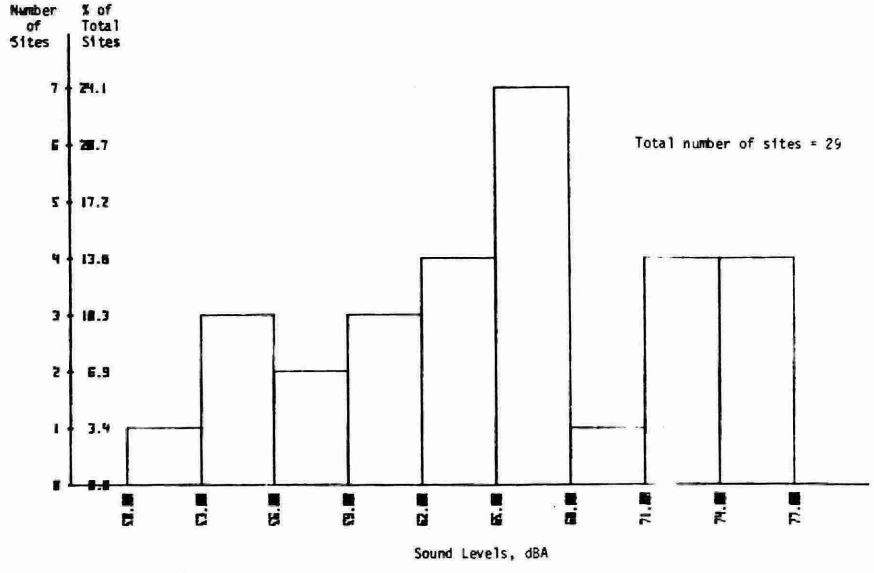

Figure 5.34 Daytime L_{10} Sound Levels in Residential-Commercial Zones

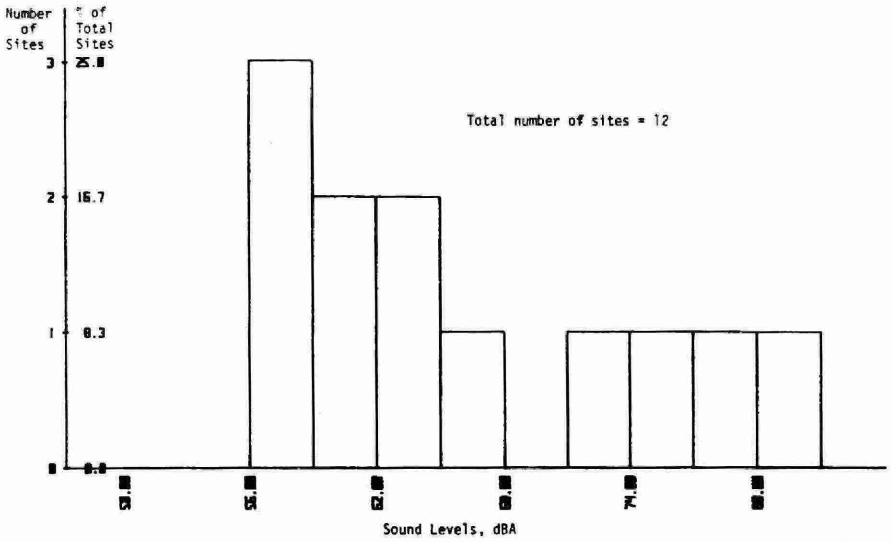

Figure 5.39 Night-time L_{10} Sound Levels in Industrial Zones

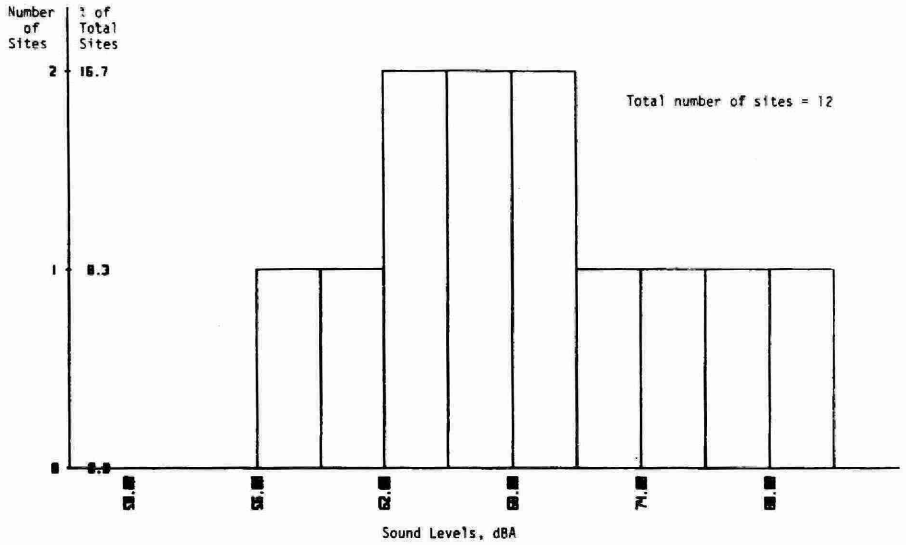

Figure 5.37 Daytime L_{10} Sound Levels in Industrial Zones

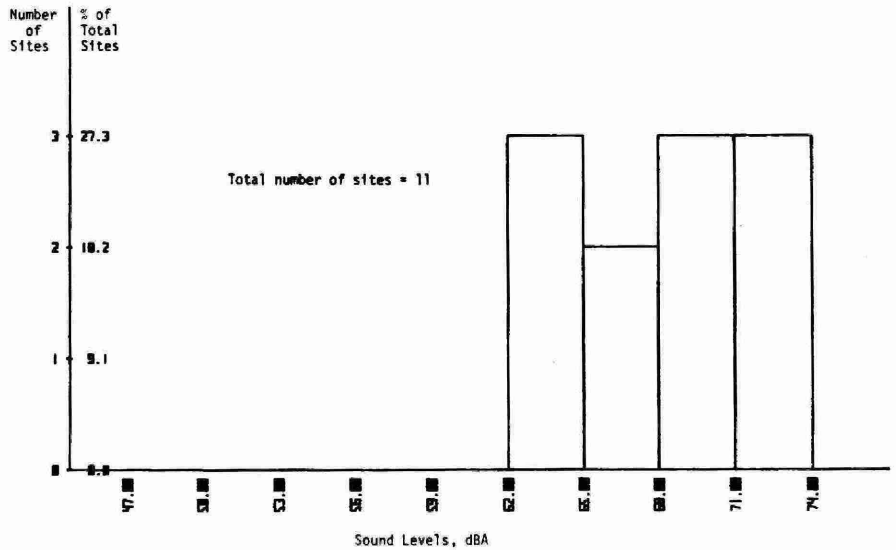

Figure 5.40 Daytime L_{10} Sound Levels in Commercial Zones

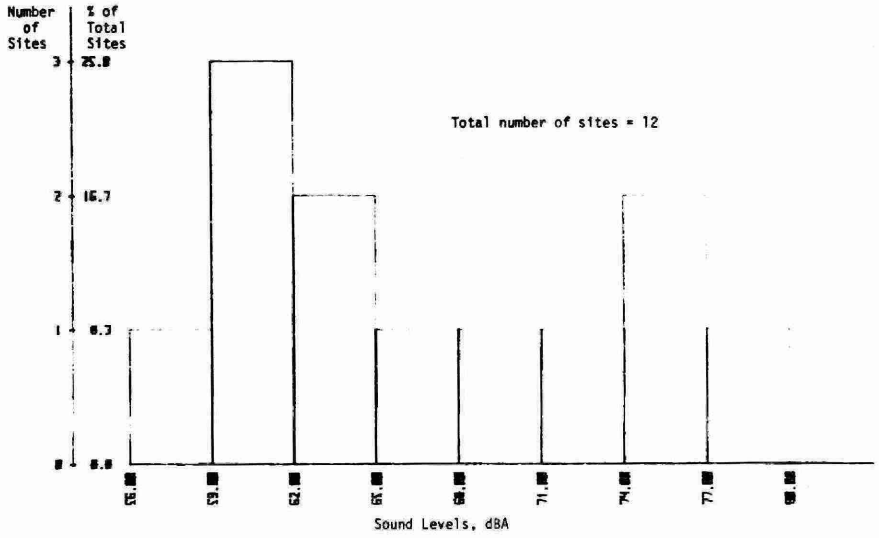

Figure 5.38 Evening L_{10} Sound Levels in Industrial Zones

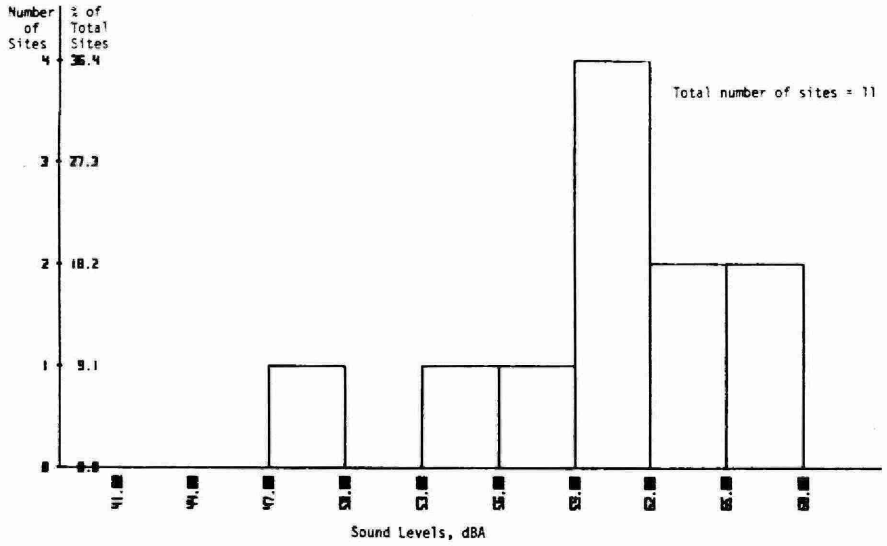

Figure 5.43 Daytime L_{10} Sound Levels in Institutional Zones

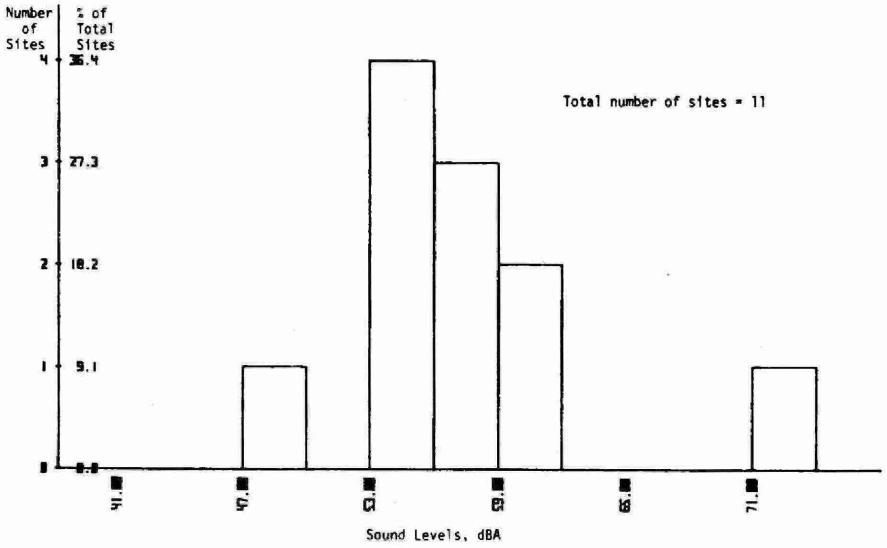

Figure 5.44 Evening L_{10} Sound Levels in Institutional Zones

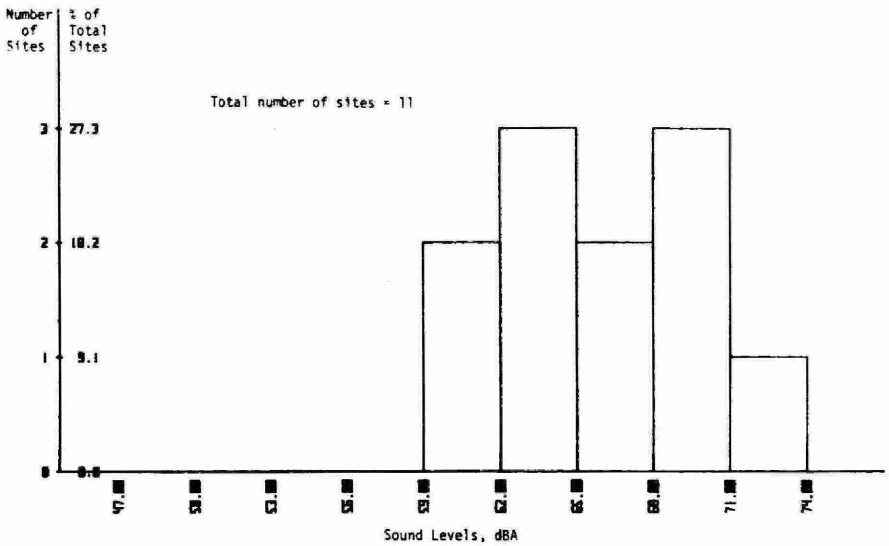

Figure 5.41 Evening L_{10} Sound Levels in Commercial Zones

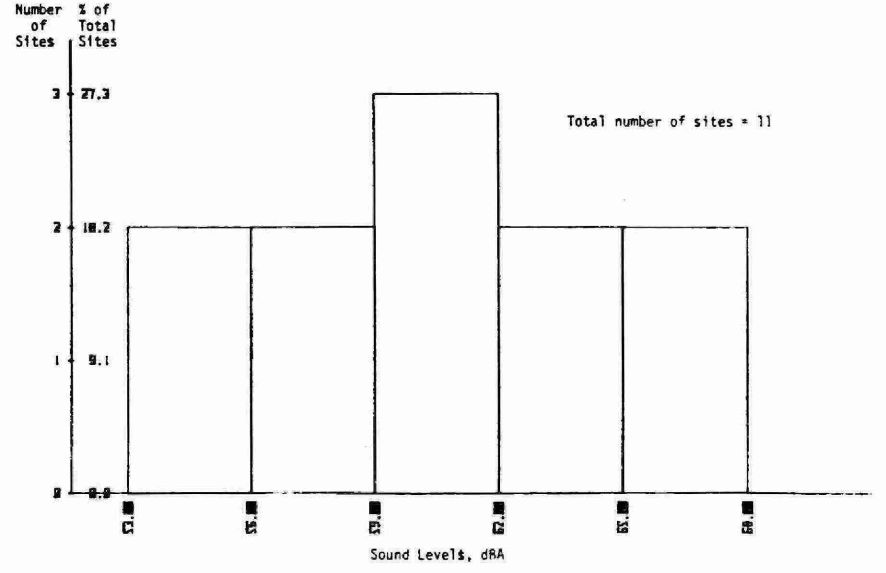

Figure 5.42 Night-time L_{10} Sound Levels in Commercial Zones

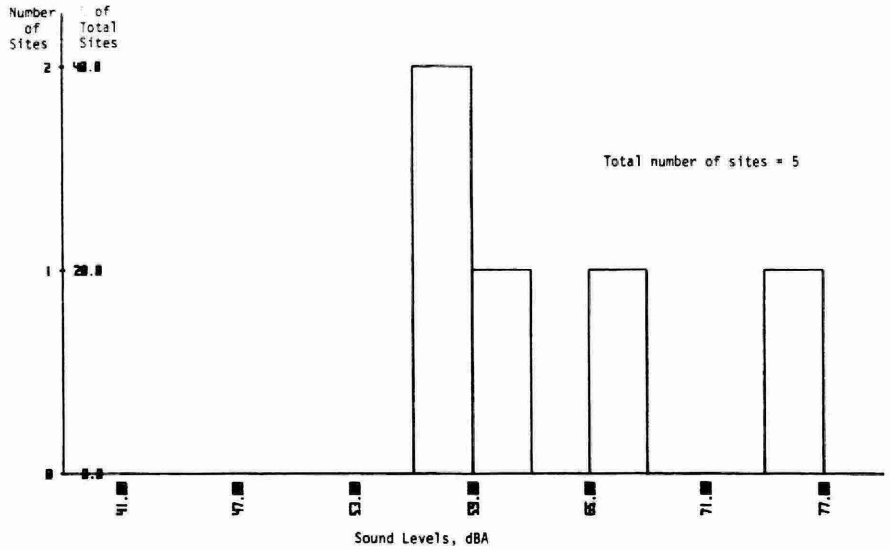

Figure 5.47 Evening L_{10} Sound Levels in Residential-Commercial-Industrial Zones

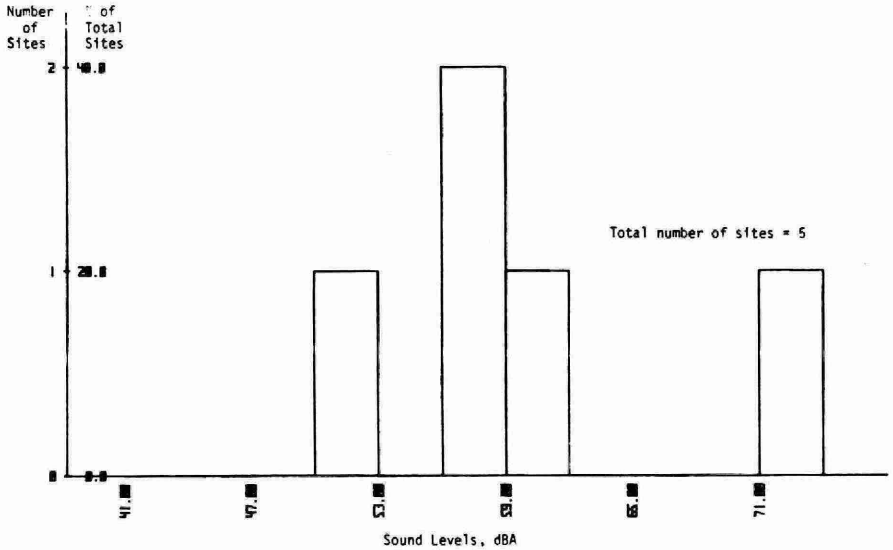

Figure 5.48 Night-time L_{10} Sound Levels in Residential-Commercial-Industrial Zones

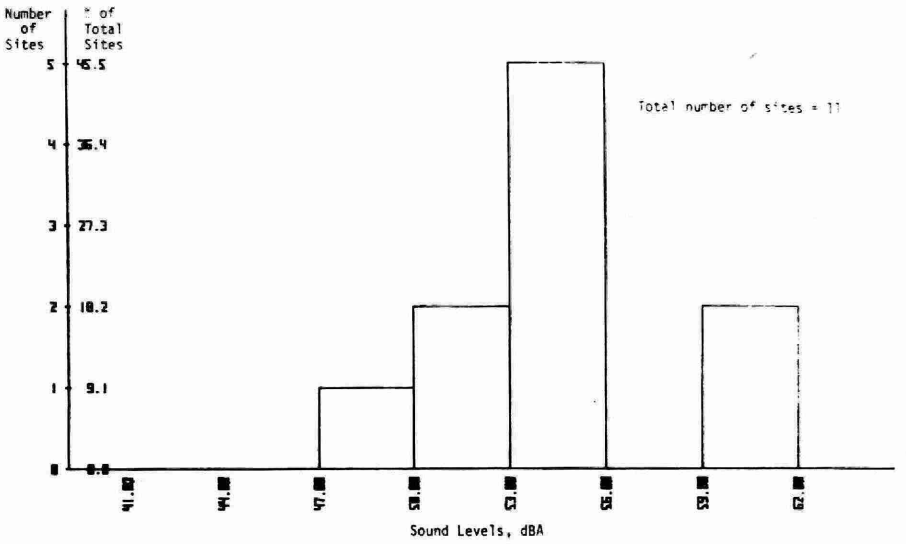

Figure 5.45 Night-time L_{10} Sound Levels in Institutional Zones

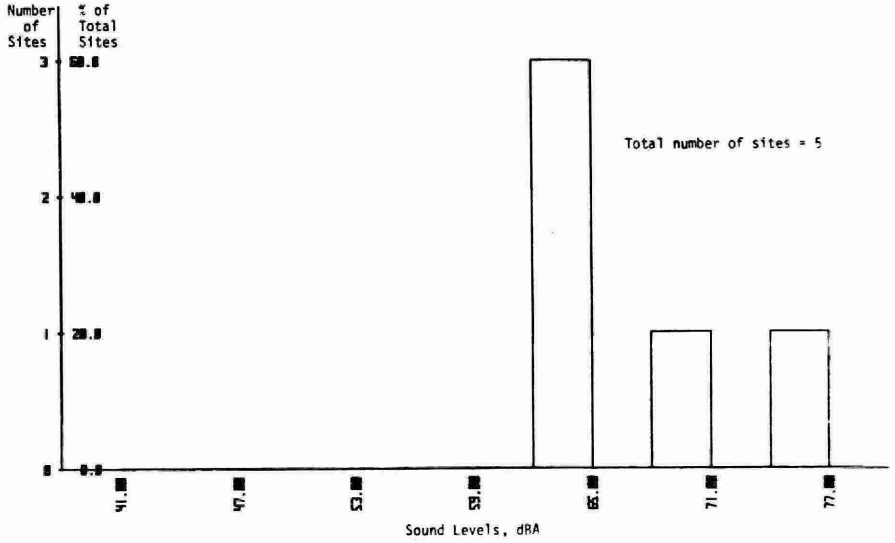

Figure 5.46 Daytime L_{10} Sound Levels in Residential-Commercial-Industrial Zones

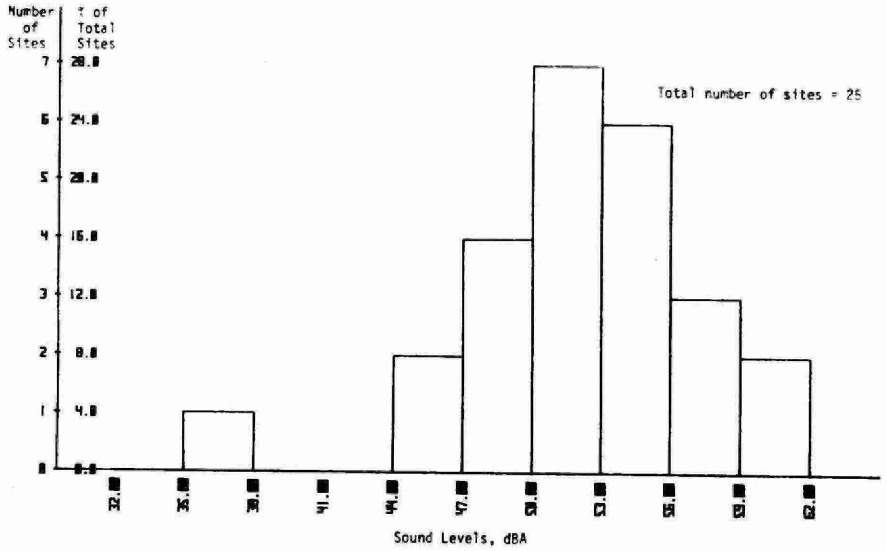

Figure 5.51 Night-time L_{eq} Sound Levels in Residential Zones

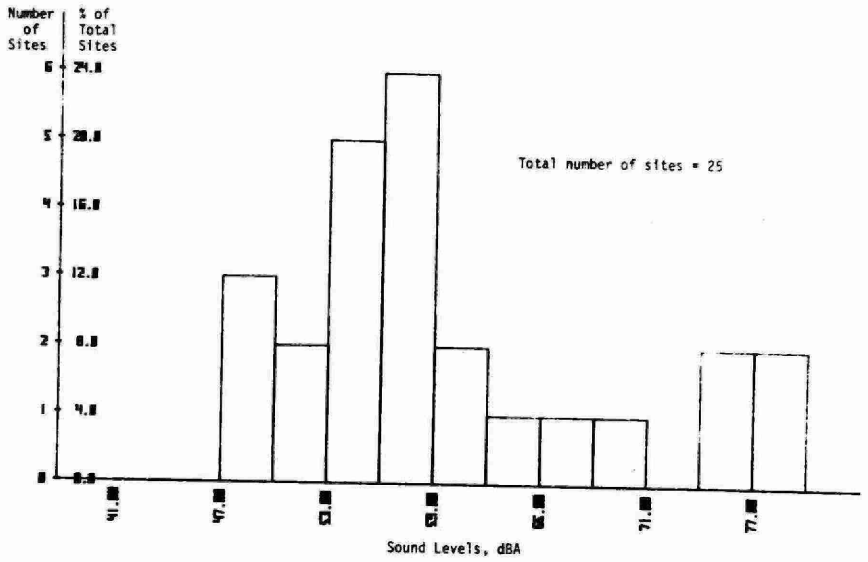

Figure 5.49 Daytime L_{eq} Sound Levels in Residential Zones

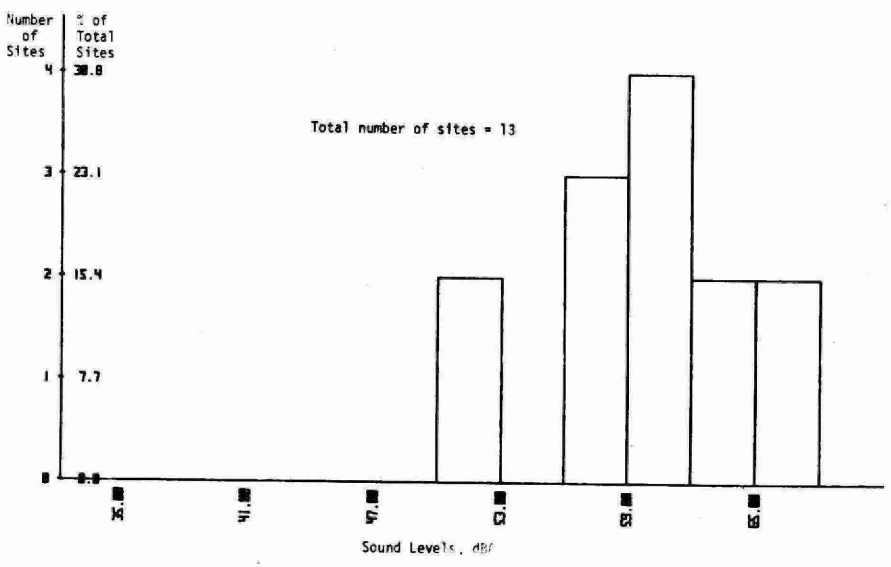

Figure 5.52 Daytime L_{eq} Sound Levels in Residential-Institutional Zones

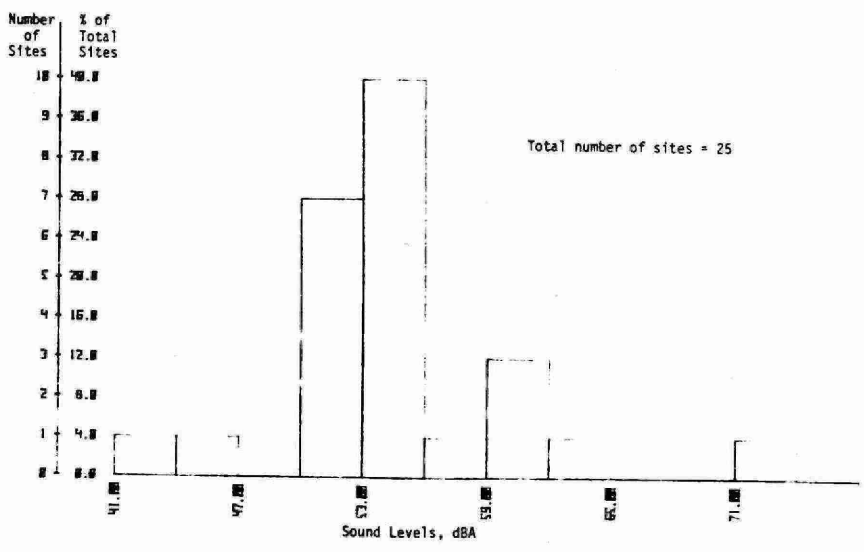

Figure 5.50 Evening L_{eq} Sound Levels in Residential Zones

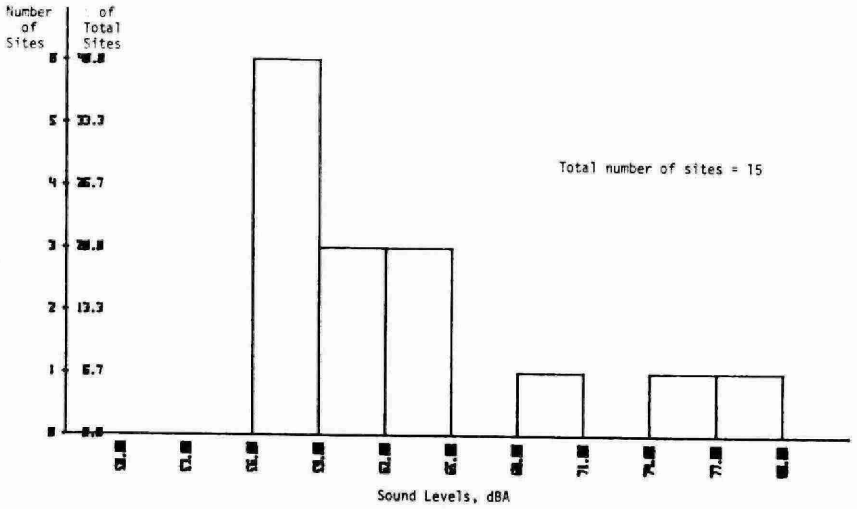

Figure 5.55 Daytime L_{eq} Sound Levels in Residential-Industrial Zones

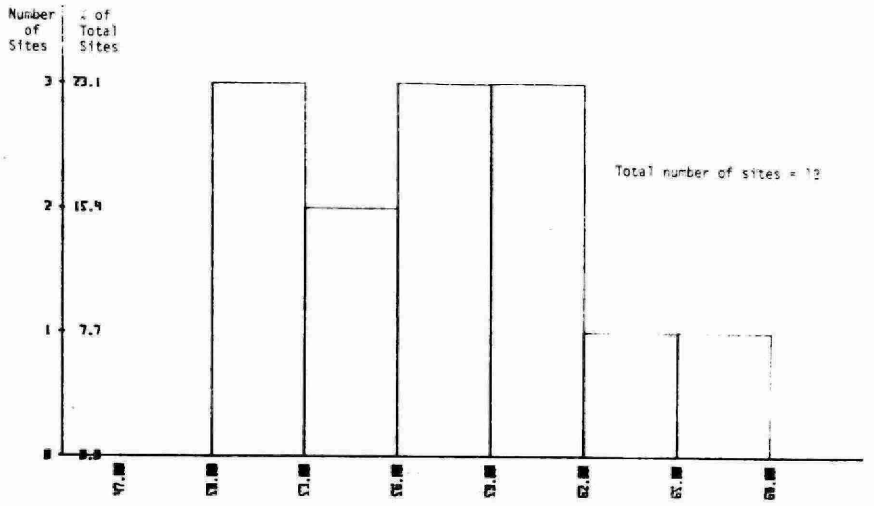

Figure 5.53 Evening L_{eq} Sound Levels in Residential-Institutional Zones

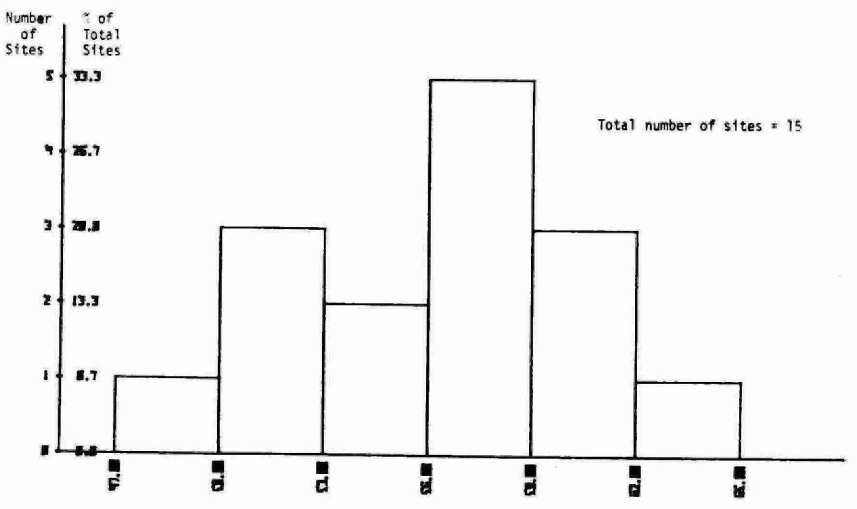

Figure 5.56 Evening L_{eq} Sound Levels in Residential-Industrial Zones

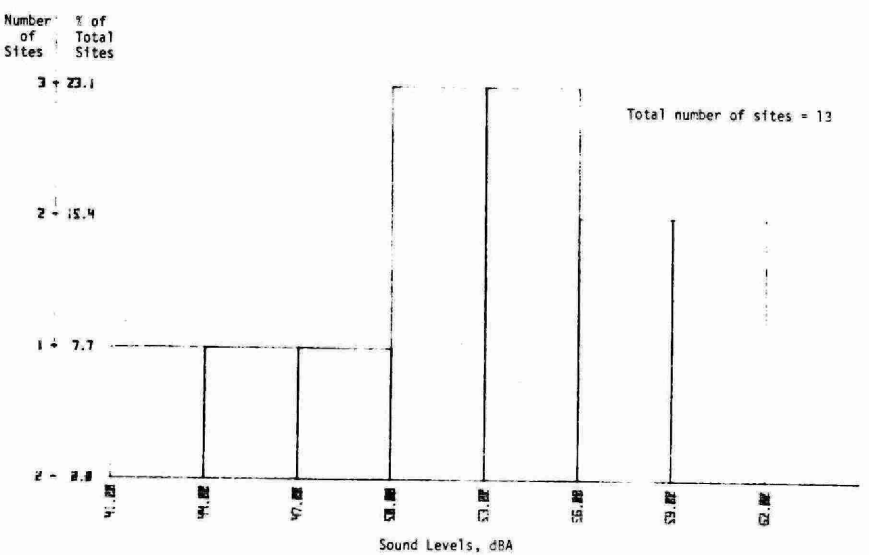

Figure 5.54 Night-time L_{eq} Sound Levels in Residential-Institutional Zones

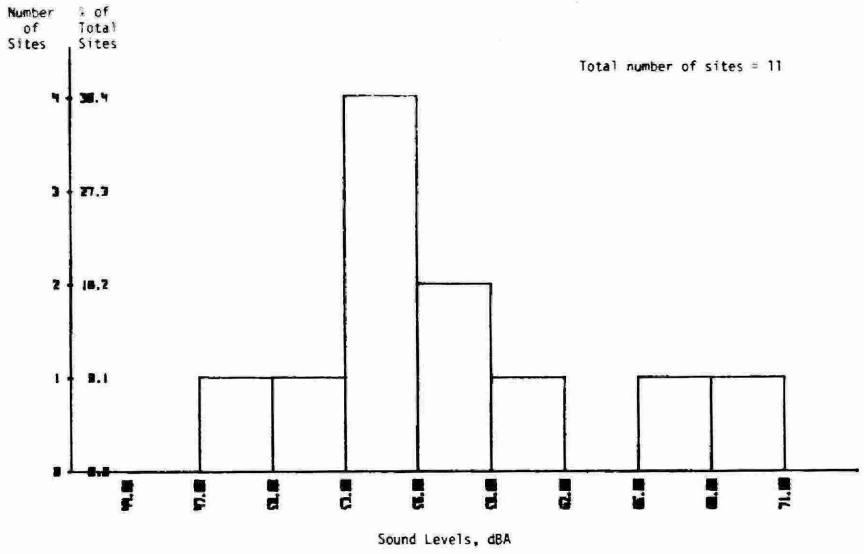

Figure 5.59 Evening L_{eq} Sound Levels in Residential-Commercial Zones

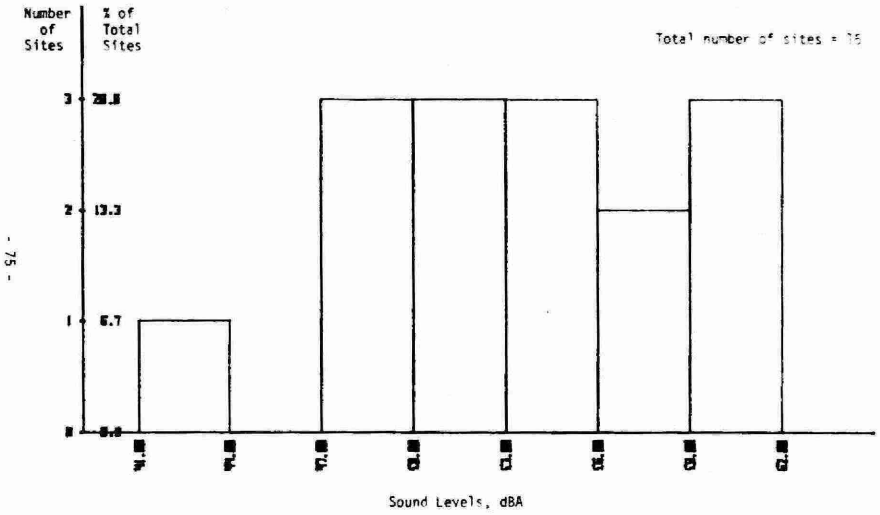

Figure 5.57 Night-time L_{eq} Sound Levels in Residential-Industrial Zones

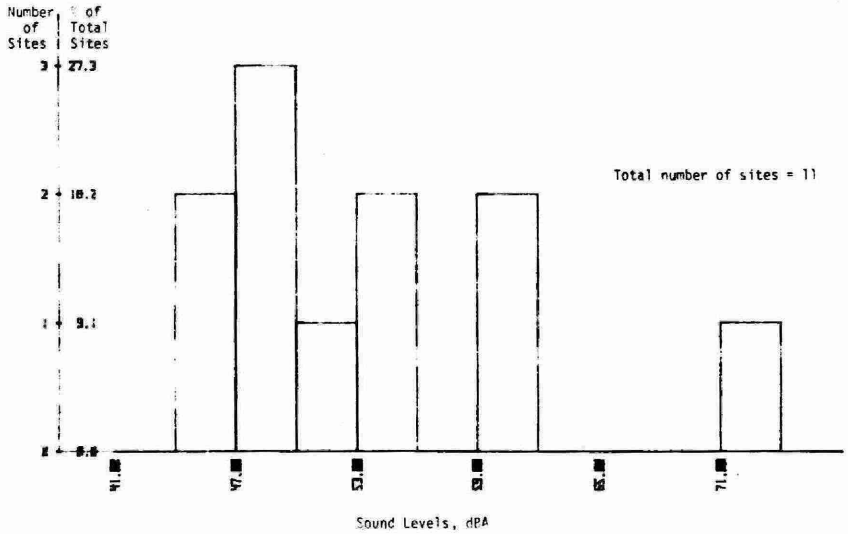

Figure 5.60 Night-time L_{eq} Sound Levels in Residential-Commercial Zones

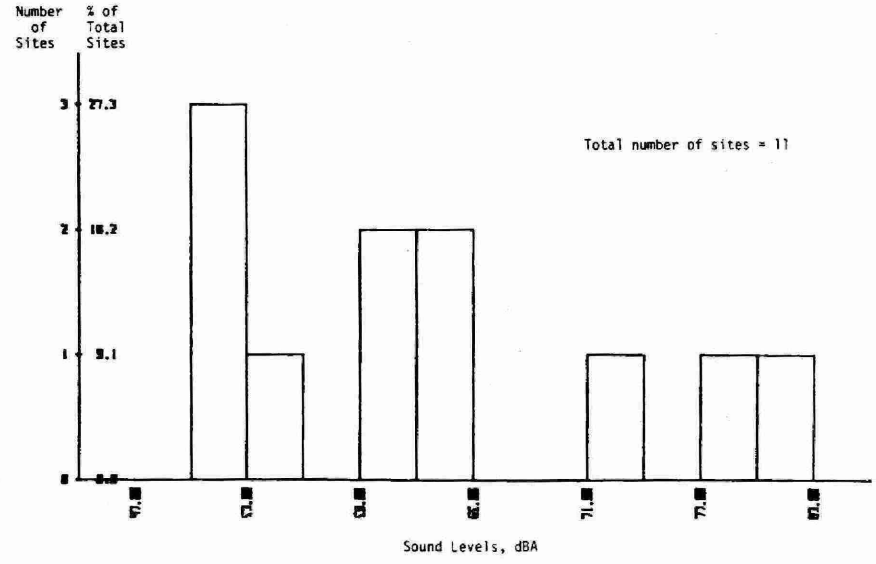

Figure 5.58 Daytime L_{eq} Sound Levels in Residential-Commercial Zones

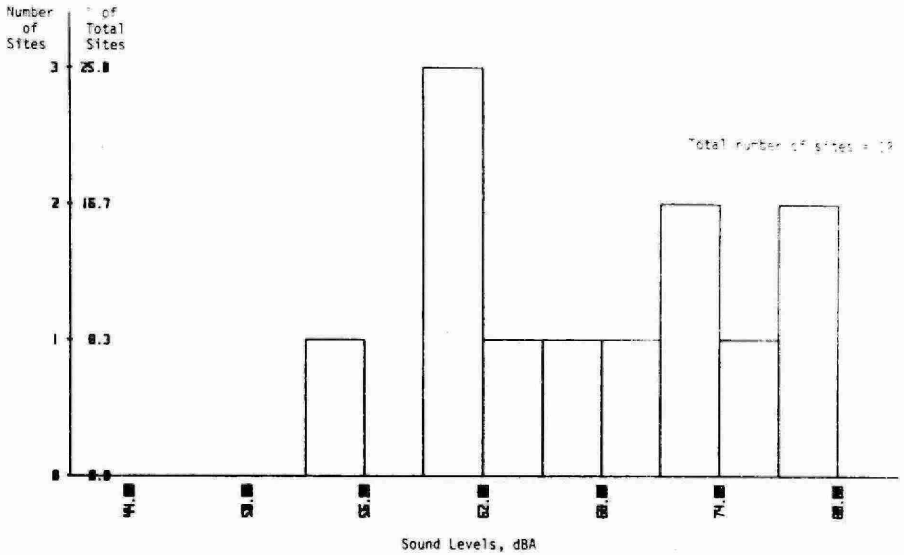

Figure 5.61 Daytime L_{eq} Sound Levels in Industrial Zones

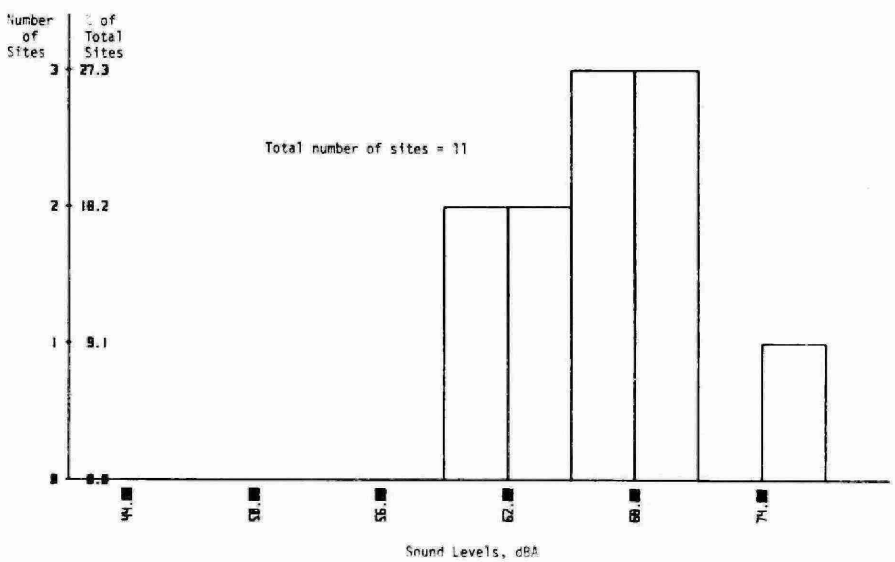

Figure 5.64 Daytime L_{eq} Sound Levels in Commercial Zones

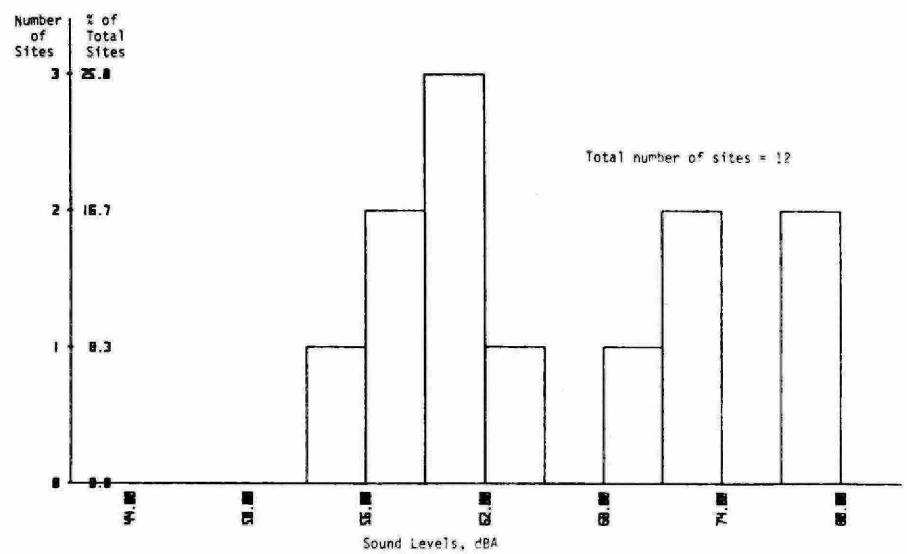

Figure 5.62 Evening L_{eq} Sound Levels in Industrial Zones

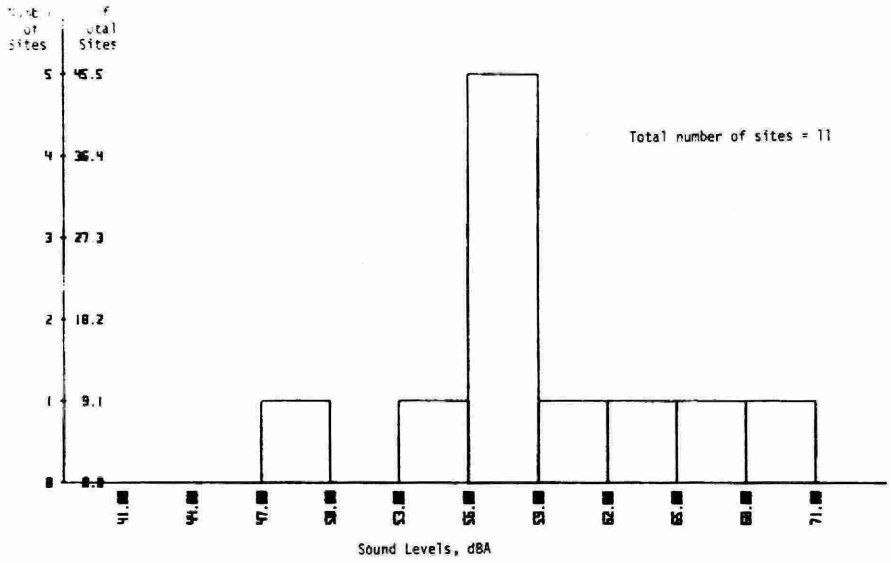

Figure 5.67 Daytime L_{eq} Sound Levels in Institutional Zones

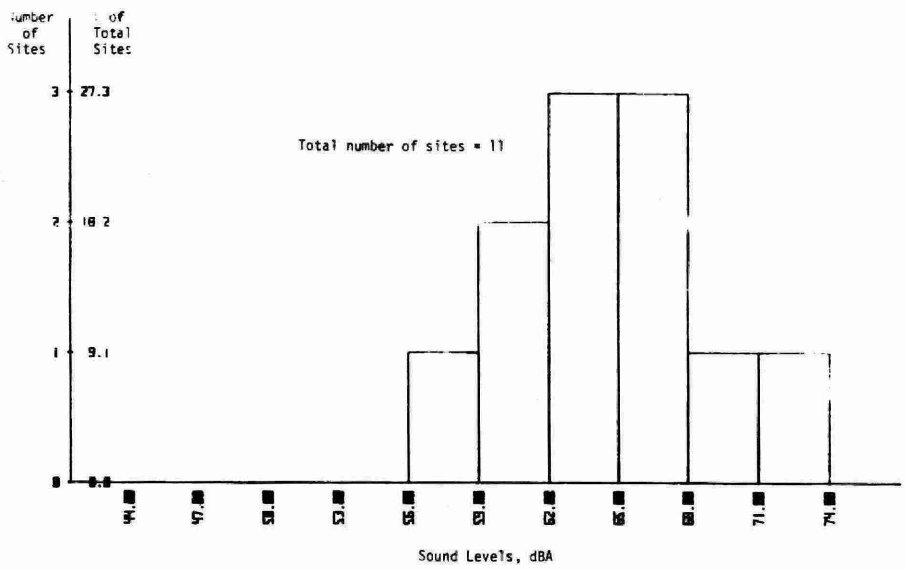

Figure 5.65 Evening L_{eq} Sound Levels in Commercial Zones

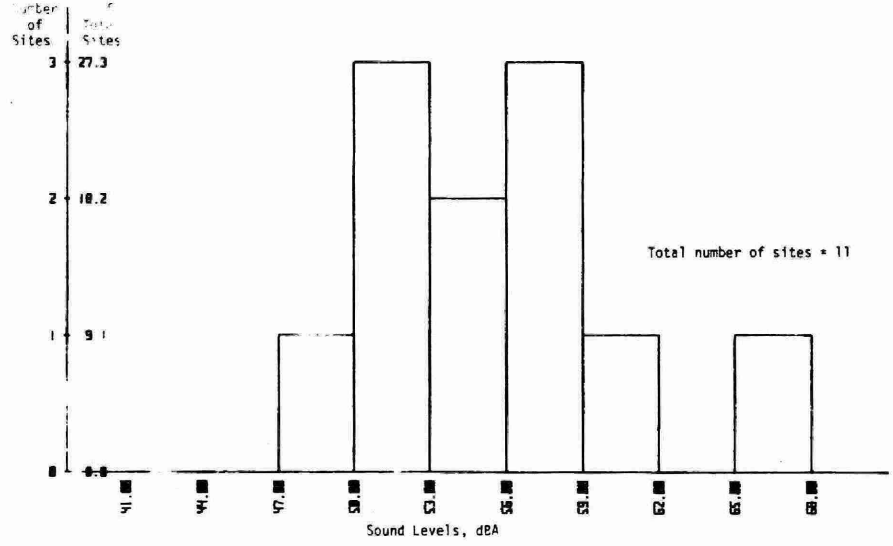

Figure 5.63 Evening L_{eq} Sound Levels in Institutional Zones

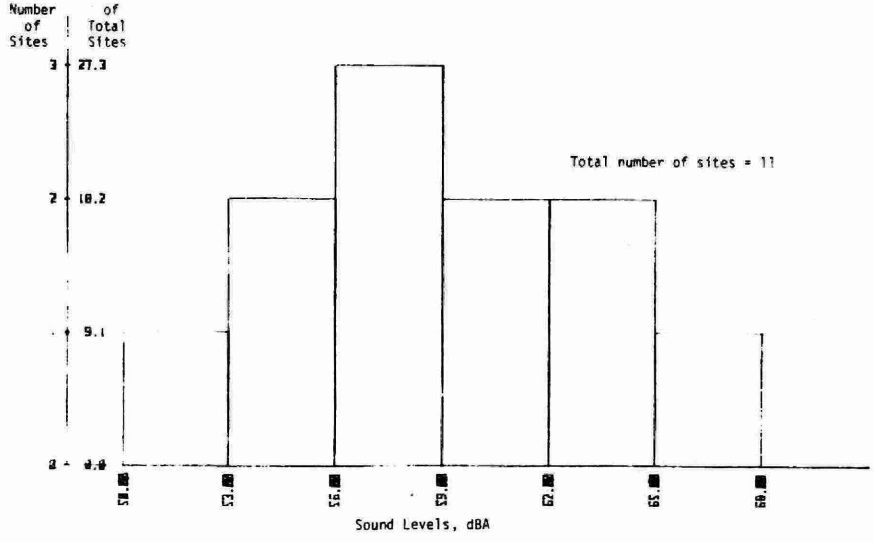

Figure 5.66 Night-time L_{eq} Sound Levels in Commercial Zones

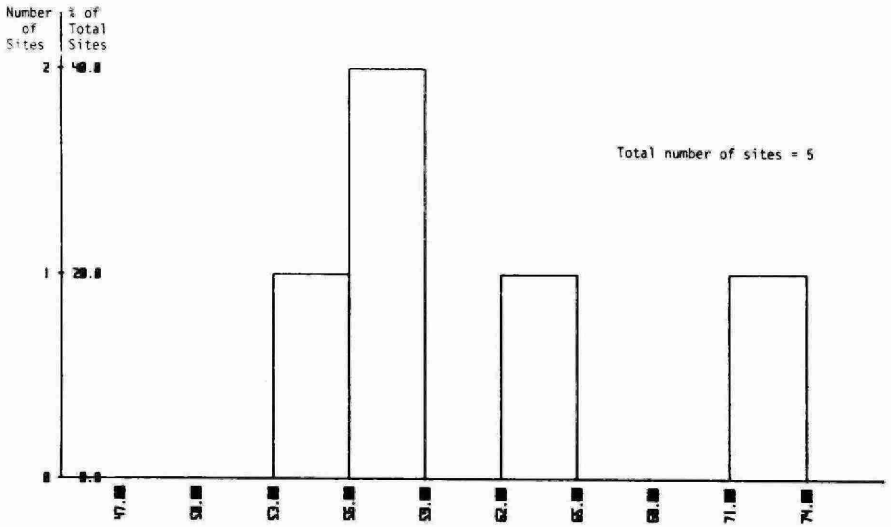

Figure 5.71 Evening L_{eq} Sound Levels in Residential-Commercial-Industrial Zones

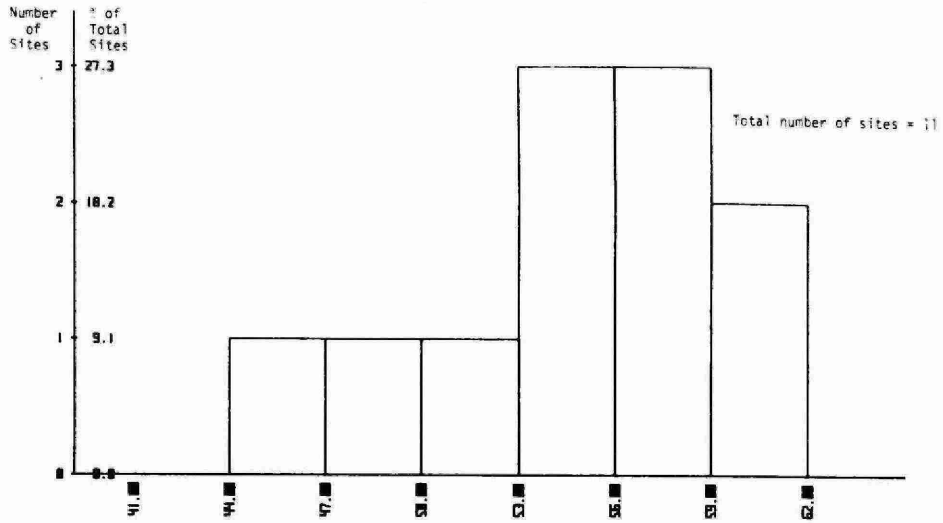

Figure 5.69 Night-time L_{eq} Sound Levels in Institutional Zones

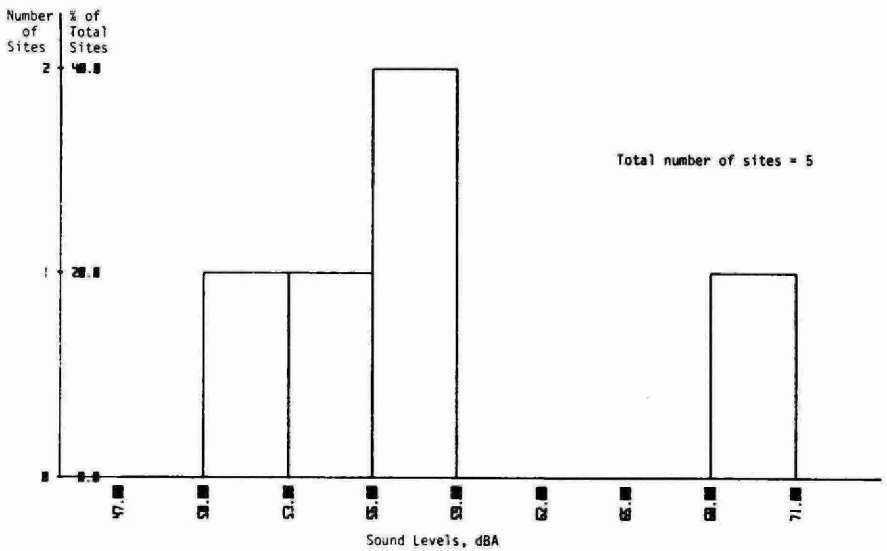

Figure 5.72 Night-time L_{eq} Sound Levels in Residential-Commercial-Industrial Zones

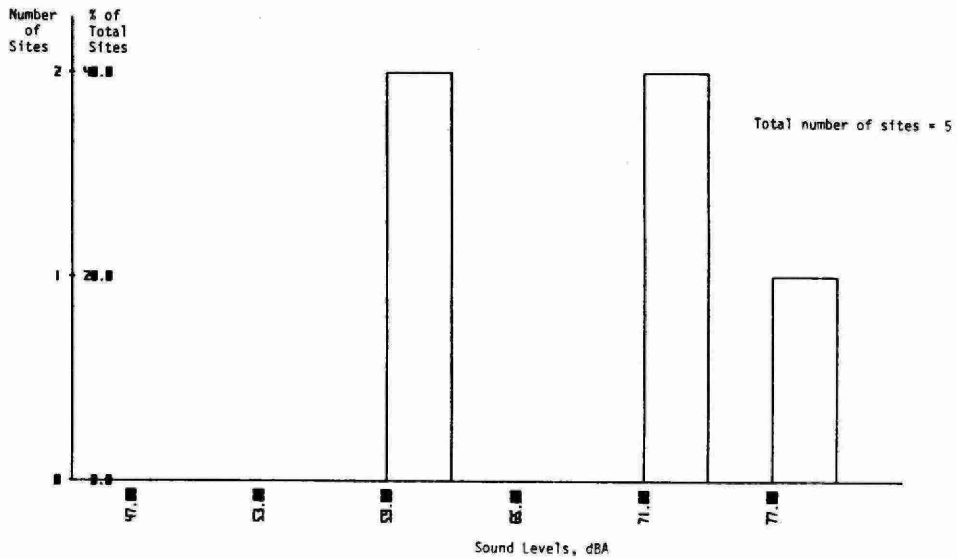

Figure 5.70 Daytime L_{eq} Sound Levels in Residential-Commercial-Industrial Zones

Type of land-use zones		Day-time (7:00-19:00 hrs.)				Evening (19:00-23:00 hrs.)				Night-time (23:00-7:00 hrs.)			
		Mean levels, in dBA	Standard deviation	No. of sites	95% Confidence limits	Mean levels, in dBA	Standard deviation	No. of sites	95% Confidence limits	Mean levels, in dBA	Standard deviation	No. of sites	95% Confidence limits
Residential	Set 1	47.6	5.8	55	± 1.6	45.5	4.7	55	± 1.3	43.4	5.3	55	± 1.4
	Set 2	47.5	6.0		± 1.6	45.6	5.1		± 1.4	43.6	6.2		± 1.7
	Average	48	5.9		± 1.6	46	4.9		± 1.4	44	5.8		± 1.6
Residential - Institutional	Set 1	48.8	4.2	22	± 1.9	47.1	3.8	22	± 1.7	44.7	4.6	22	± 2.0
	Set 2	48.2	4.7		± 2.1	46.9	4.3		± 1.9	44.3	4.6		± 2.0
	Average	49	4.5		± 2.0	47	4.1		± 1.8	45	4.6		± 2.0
Residential - Industrial	Set 1	48.0	5.7	31	± 2.1	46.7	5.0	31	± 1.8	44.3	5.1	31	± 1.9
	Set 2	48.0	5.5		± 2.0	46.8	4.7		± 1.7	45.0	5.1		± 1.9
	Average	48	5.6		± 2.1	47	4.9		± 1.8	45	5.1		± 1.9
Residential - Commercial	Set 1	51.2	6.4	29	± 2.4	49.1	6.2	29	± 2.4	44.3	5.2	29	± 2.0
	Set 2	49.8	6.6		± 2.5	48.2	6.9		± 2.6	44.1	6.9		± 2.6
	Average	51	6.5		± 2.5	49	6.6		± 2.5	44	6.1		± 2.3
Industrial	Set 1	56.1	7.8	12	± 5.0	56.0	7.9	12	± 5.0	55.7	8.8	12	± 5.6
	Set 2	56.0	9.1		± 5.8	56.3	8.8		± 5.6	56.0	9.3		± 5.9
	Average	56	8.5		± 5.4	56	8.4		± 5.3	56	9.1		± 5.8
Commercial	Set 1	58.0	3.0	11	± 2.0	51.4	3.1	11	± 2.1	46.3	3.7	11	± 2.5
	Set 2	51.8	4.2		± 2.8	51.4	3.2		± 2.2	46.4	3.0		± 2.0
	Average	52	3.6		± 2.4	51	3.2		± 2.2	46	3.4		± 2.3
Institutional	Set 1	45.6	3.2	11	± 2.2	45.4	3.4	11	± 2.3	42.8	5.2	11	± 3.5
	Set 2	44.1	3.9		± 2.6	44.6	3.5		± 2.4	42.7	5.2		± 3.5
	Average	45	3.6		± 2.4	45	3.5		± 2.4	43	5.2		± 3.5
Residential - Commercial - Industrial	Set 1	49.5	5.3	5	± 6.6	48.6	5.0	5	± 6.2	46.2	4.9	5	± 6.1
	Set 2	48.4	5.4		± 6.7	46.6	5.0		± 6.2	44.2	6.6		± 8.2
	Average	49	5.4		± 6.7	48	5.0		± 6.2	45	5.8		± 7.2

Table 5.1: Weekday L_{90} Sound Levels in Ontario Communities

Type of land-use zones		Day-time (7:00-19:00 hrs.)				Evening (19:00 - 23:00 hrs.)				Night-time (23:00 - 7:00 hrs.)			
		Mean levels, in dBA	Standard deviation	No. of sites	95% Confidence limits	Mean levels, in dBA	Standard deviation	No. of sites	95% Confidence limits	Mean levels, in dBA	Standard deviation	No. of sites	95% Confidence limits
Residential	Set 1	60.3	7.0	55	± 1.9	56.9	6.7	55	± 1.8	54.7	6.7	55	± 1.8
	Set 2	60.8	6.9		± 1.9	58.1	8.4		± 2.3	55.2	7.3		± 2.0
	Average	61	7.0		± 1.9	58	7.6		± 2.1	55	7.0		± 1.9
Residential - Institutional	Set 1	62.0	4.9	22	± 2.2	59.7	5.0	22	± 2.2	54.3	5.0	22	± 2.2
	Set 2	61.6	5.4		± 2.4	58.9	5.4		± 2.4	54.4	4.6		± 2.0
	Average	62	5.2		± 2.3	59	5.2		± 2.3	54	4.8		± 2.1
Residential - Industrial	Set 1	62.0	6.3	31	± 2.3	58.9	7.0	31	± 2.6	57.3	6.1	31	± 2.2
	Set 2	63.0	6.1		± 2.2	58.3	6.6		± 2.4	58.3	6.1		± 2.2
	Average	63	6.2		± 2.3	59	6.8		± 2.5	58	6.1		± 2.2
Residential- Commercial	Set 1	64.8	6.8	29	± 2.6	61.8	6.5	29	± 2.5	59.2	7.3	29	± 2.8
	Set 2	63.4	6.8		± 2.6	61.4	7.0		± 2.7	57.8	7.7		± 2.9
	Average	64	6.8		± 2.6	62	6.8		± 2.6	59	7.5		± 2.9
Industrial	Set 1	68.2	7.2	12	± 4.6	66.2	7.4	12	± 4.7	65.6	8.3	12	± 5.3
	Set 2	68.5	7.0		± 4.5	66.2	7.4		± 4.7	66.2	8.9		± 5.7
	Average	68	7.1		± 4.6	66	7.4		± 4.7	66	8.6		± 5.5
Commercial	Set 1	67.9	3.6	11	± 2.4	66.1	3.8	11	± 2.6	60.7	4.3	11	± 2.9
	Set 2	66.0	3.6		± 2.4	65.5	3.7		± 2.5	60.1	4.5		± 3.0
	Average	67	3.6		± 2.4	66	3.8		± 2.6	60	4.4		± 3.0
Institutional	Set 1	59.7	4.9	11	± 3.3	57.2	5.6	11	± 3.8	52.6	5.2	11	± 3.5
	Set 2	59.4	5.4		± 3.6	56.2	4.9		± 3.3	52.4	5.7		± 3.8
	Average	60	5.2		± 3.5	57	5.3		± 3.6	53	5.5		± 3.7
Residential- Commercial- Industrial	Set 1	66.0	6.5	5	± 8.1	63.0	8.7	5	± 10.8	59.0	9.1	5	± 11.3
	Set 2	66.0	5.0		± 6.2	62.4	7.3		± 9.1	59.2	7.3		± 9.1
	Average	66	5.8		± 7.2	63	8.0		± 10.0	59	8.2		± 10.2

Table 5.2: Weekday L_{10} Sound Levels in Ontario Communities

Type of land-use zones		Day-time (7:00-19:00 hrs.)				Evening (19:00-23:00 hrs.)				Night-time (23:00-7:00 hrs.)			
		Mean levels, in dBA	Standard deviation	No. of sites	95% Confidence limits	Mean levels, in dBA	Standard deviation	No. of sites	95% Confidence limits	Mean levels, in dBA	Standard deviation	No. of sites	95% Confidence limits
Residential	Set 1	59.2	9.4	25	± 3.9	54.3	5.9	25	± 2.4	51.7	5.0	25	± 2.1
	Set 2	60.2	9.9		± 4.1	54.8	5.0		± 2.1	51.3	5.7		± 2.4
	Average	60	9.7		± 4.0	55	5.5		± 2.2	52	5.4		± 2.3
Residential - Institutional	Set 1	59.4	4.6	13	± 2.8	56.8	4.8	13	± 2.9	53.0	4.4	13	± 2.7
	Set 2	61.1	8.3		± 5.0	55.1	5.9		± 3.6	52.7	5.0		± 3.0
	Average	60	6.5		± 3.6	56	5.4		± 3.3	53	4.7		± 2.9
Residential - Industrial	Set 1	62.2	7.0	15	± 3.9	55.7	4.3	15	± 2.4	53.0	5.2	15	± 2.9
	Set 2	64.1	7.2		± 4.0	55.3	3.6		± 2.0	53.5	5.3		± 2.9
	Average	63	7.1		± 4.0	56	4.0		± 2.2	53	5.3		± 2.9
Residential Commercial	Set 1	62.3	10.0	11	± 6.7	56.7	6.3	11	± 4.2	53.3	7.6	11	± 5.1
	Set 2	62.0	8.9		± 6.0	57.2	6.0		± 4.0	52.8	6.9		± 4.6
	Average	62	9.5		± 6.4	57	6.2		± 4.1	53	7.3		± 4.9
Industrial	Set 1	67.5	8.7	12	± 5.5	64.3	7.7	12	± 4.9	65.1	8.9	12	± 5.7
	Set 2	67.5	7.5		± 4.8	66.0	7.8		± 5.0	65.0	8.4		± 5.3
	Average	68	8.1		± 5.2	65	7.8		± 5.0	65	8.7		± 5.5
Commercial	Set 1	66.4	4.6	11	± 3.1	64.0	4.2	11	± 2.8	58.6	4.5	11	± 3.0
	Set 2	65.2	4.5		± 3.0	62.7	4.6		± 3.1	57.9	4.5		± 3.0
	Average	66	4.6		± 3.1	63	4.4		± 3.0	58	4.5		± 3.0
Institutional	Set 1	58.4	6.0	11	± 4.0	55.7	5.7	11	± 3.8	54.1	4.7	11	± 3.2
	Set 2	58.8	6.1		± 4.1	55.2	4.9		± 3.3	52.2	4.8		± 3.2
	Average	59	6.1		± 4.1	55	5.3		± 3.6	53	4.8		± 3.2
Residential - Commercial - Industrial	Set 1	68.4	7.7	5	± 9.6	62.2	8.6	5	± 10.7	58.0	9.2	5	± 11.4
	Set 2	68.0	7.7		± 9.6	60.6	7.4		± 9.2	57.2	6.6		± 8.2
	Average	68	7.7		± 9.6	61	8.0		± 10.5	58	7.9		± 9.8

Table 5.3: Weekday L_{eq} Sound Levels in Ontario Communities

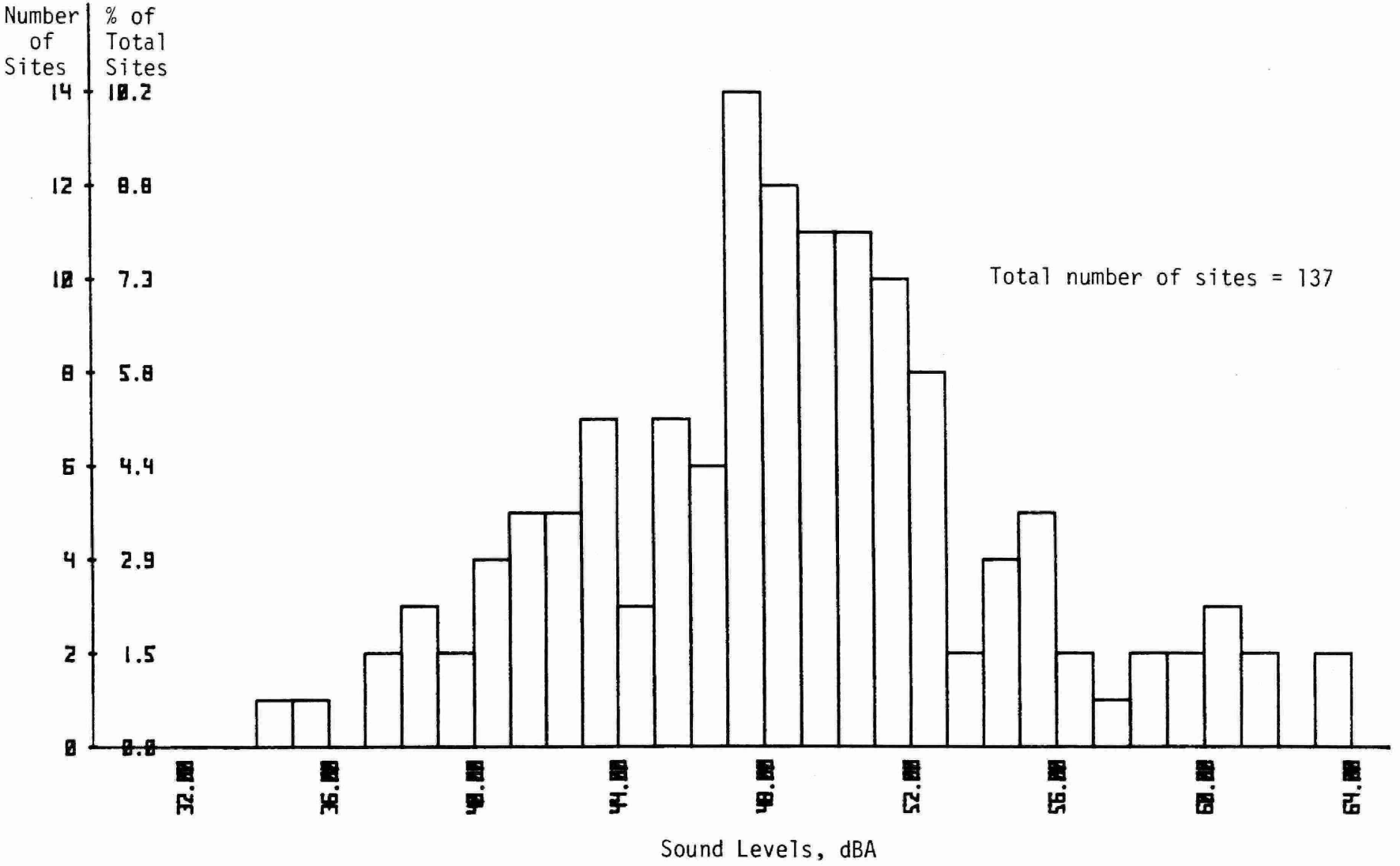

Figure 5.73 Daytime L_{90} Sound Levels at Residential Sites

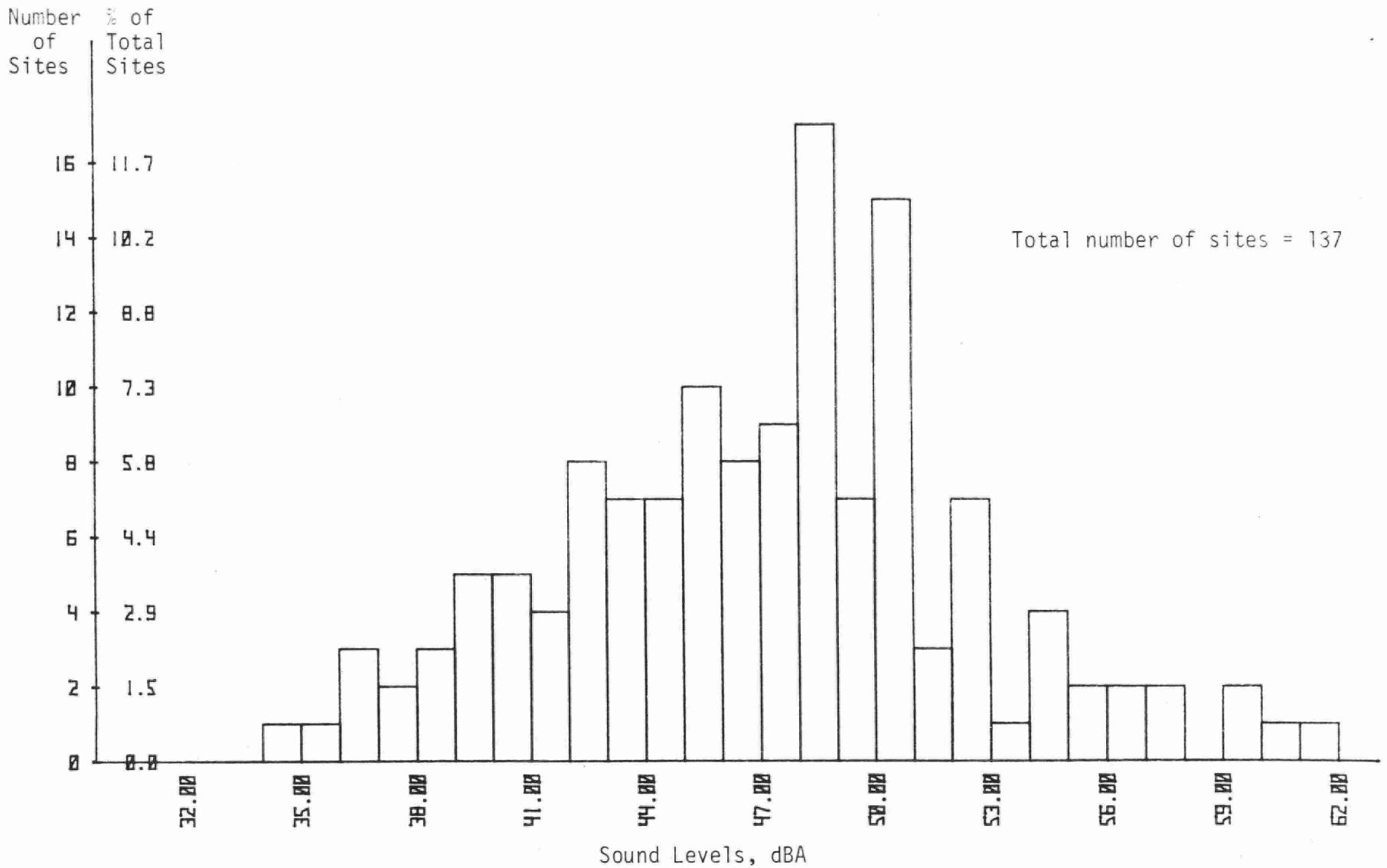

Figure 5.74 Evening L_{90} Sound Levels at Residential Sites

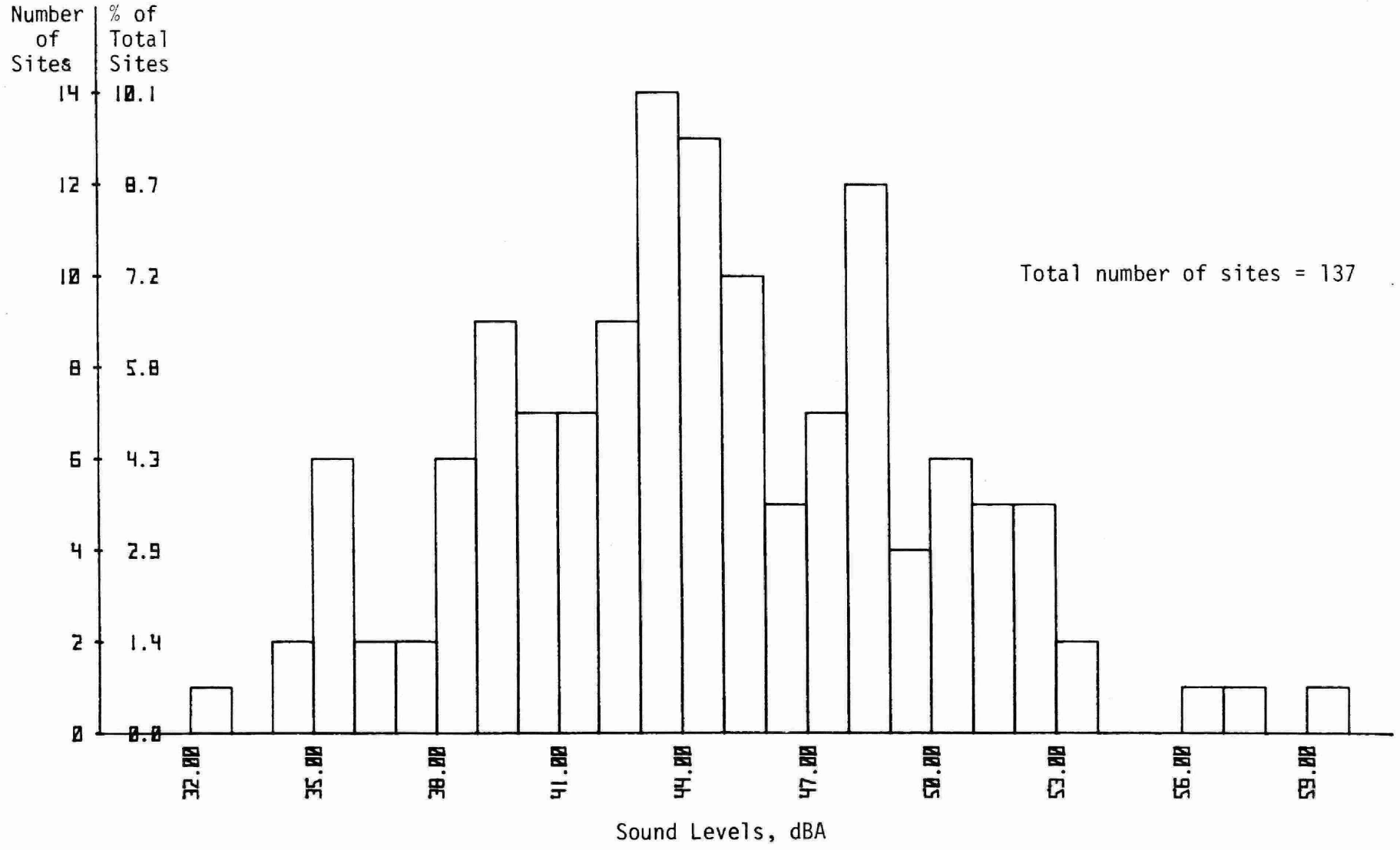

Figure 5.75 Night-time L_{90} Sound Levels at Residential Sites

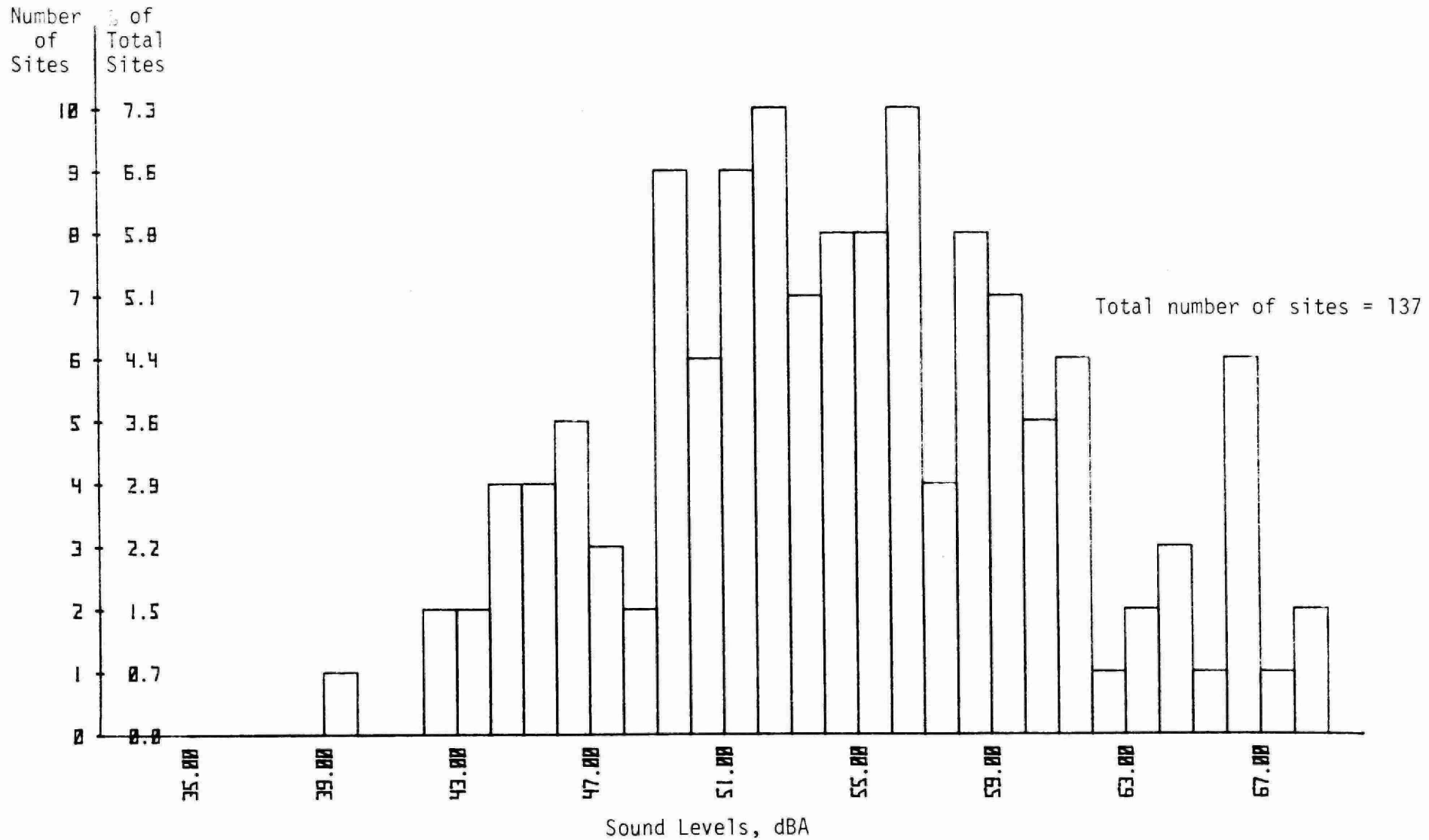

Figure 5.76 Daytime L_{50} Sound Levels at Residential Sites

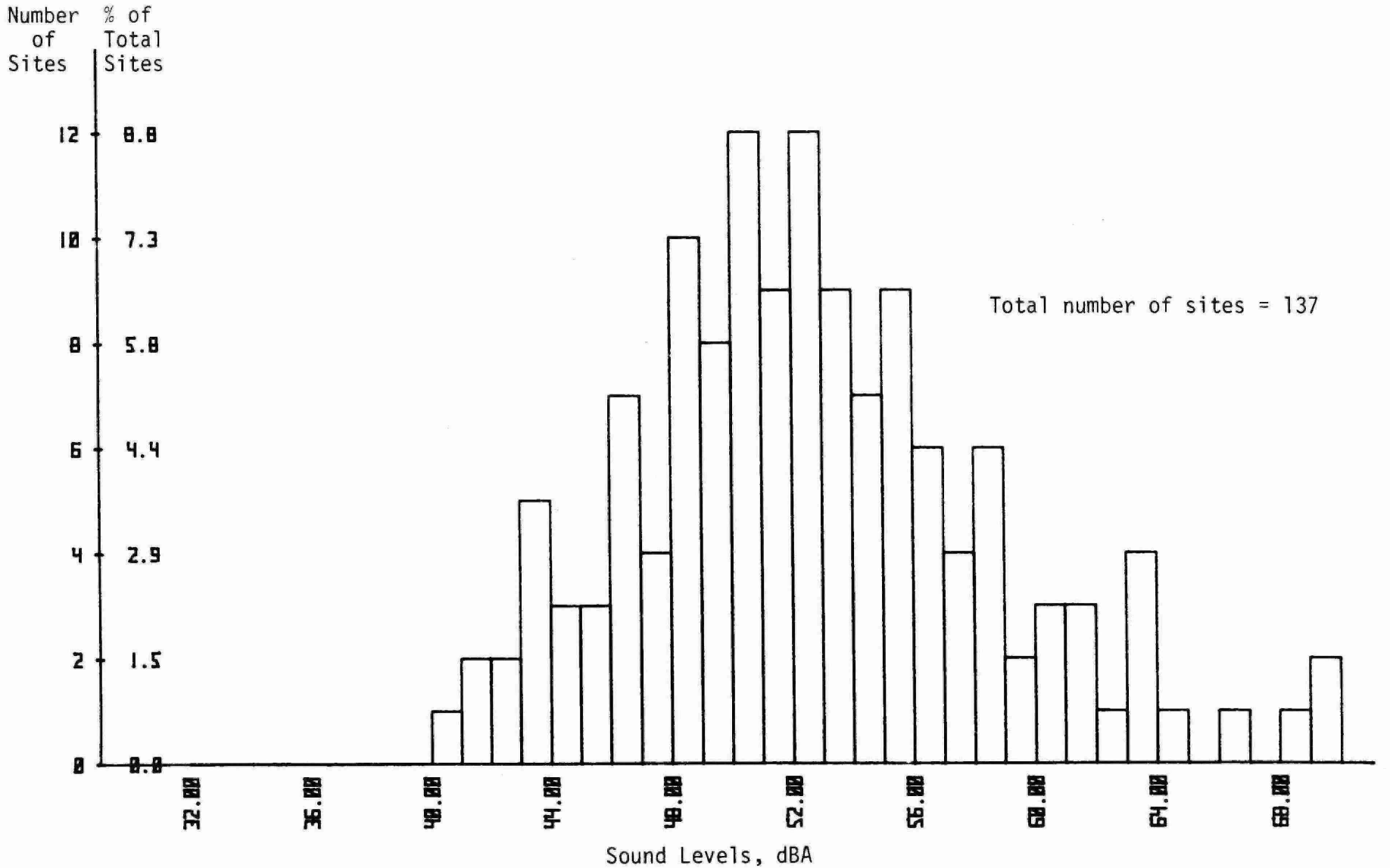

Figure 5.77 Evening L_{50} Sound Levels at Residential Sites

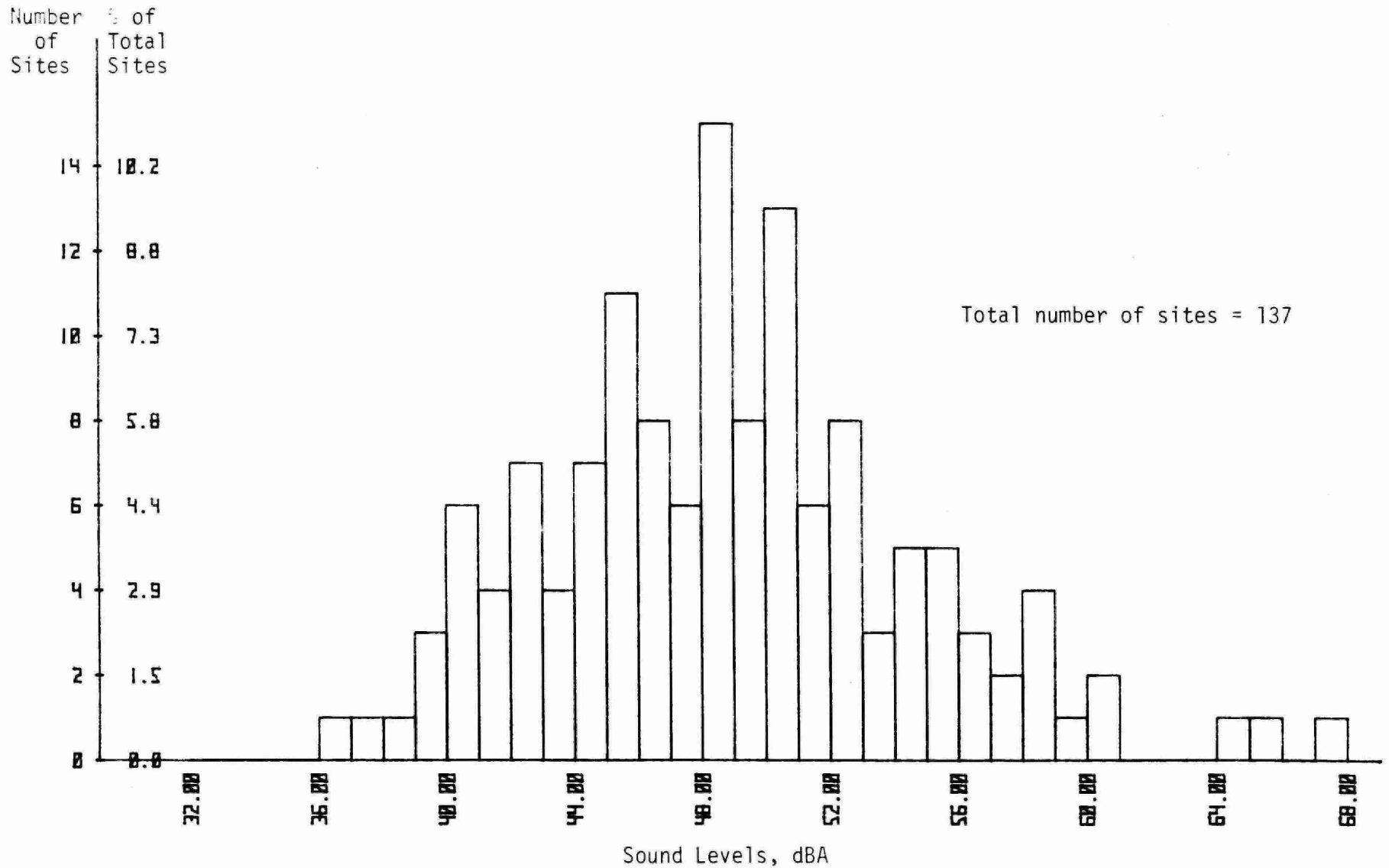

Figure 5.78 Night-time L_{50} Sound Levels at Residential Sites

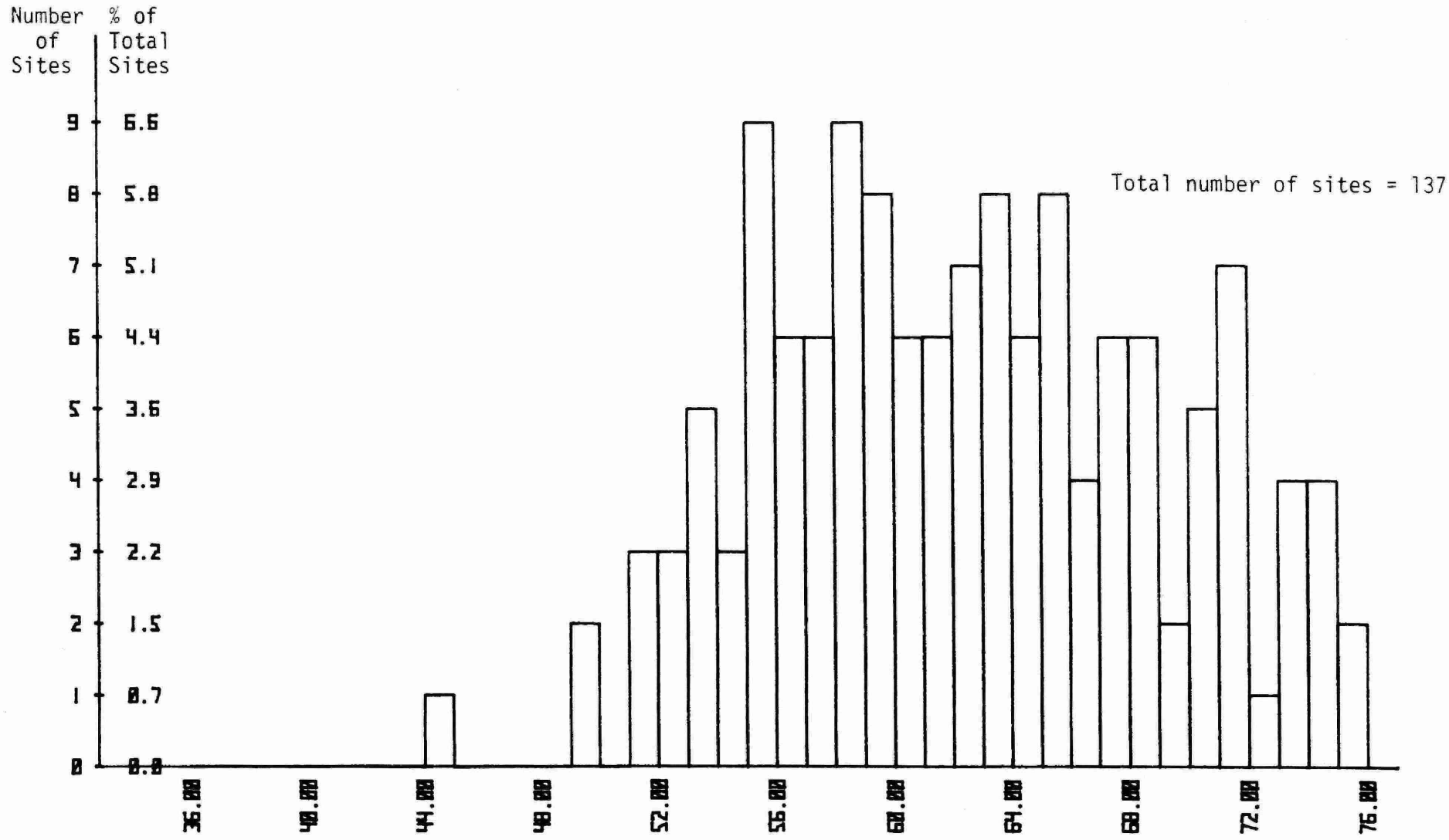

Figure 5.79 Daytime L_{10} Sound Levels at Residential Sites

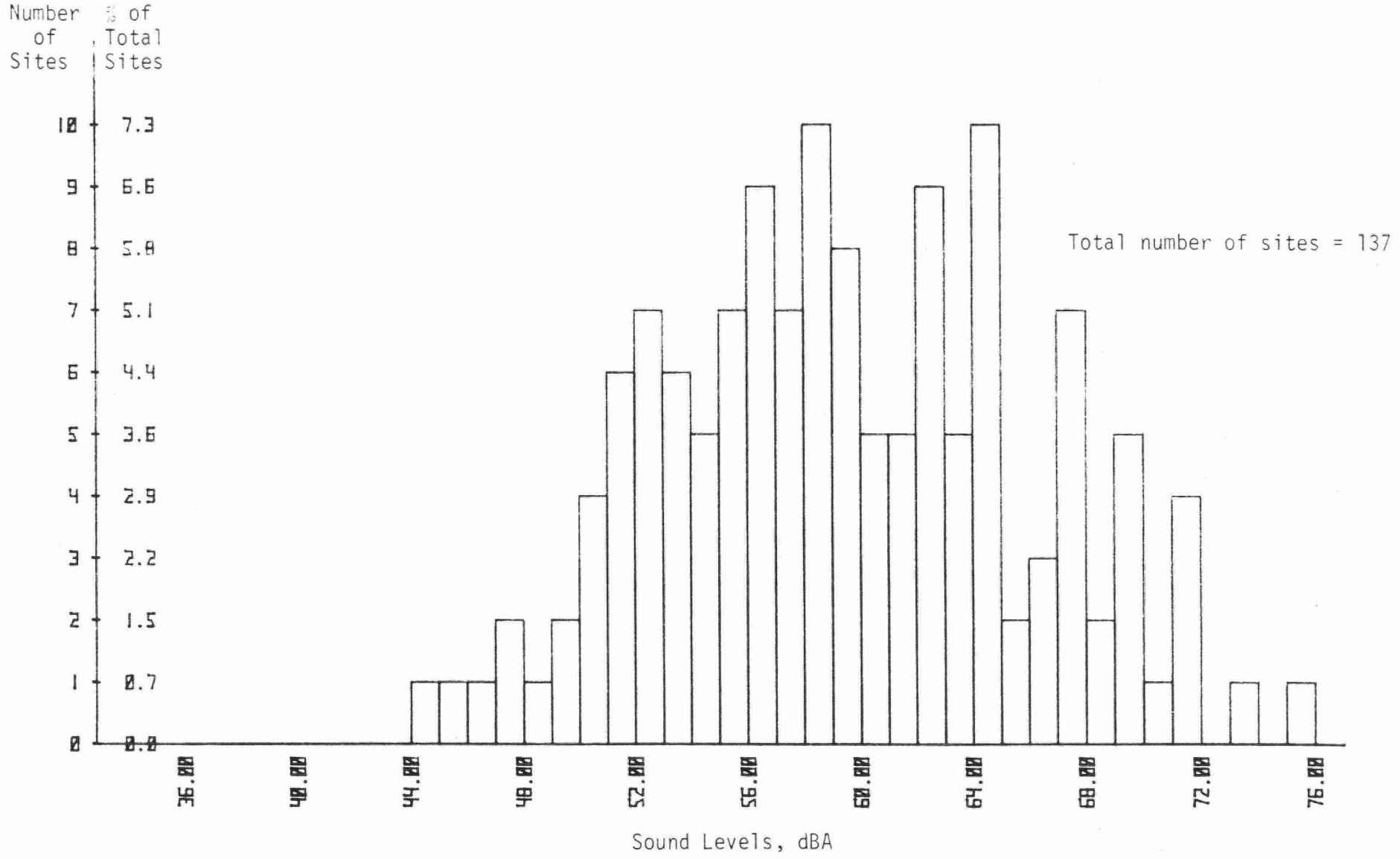

Figure 5.80 Evening L_{10} Sound Levels at Residential Sites

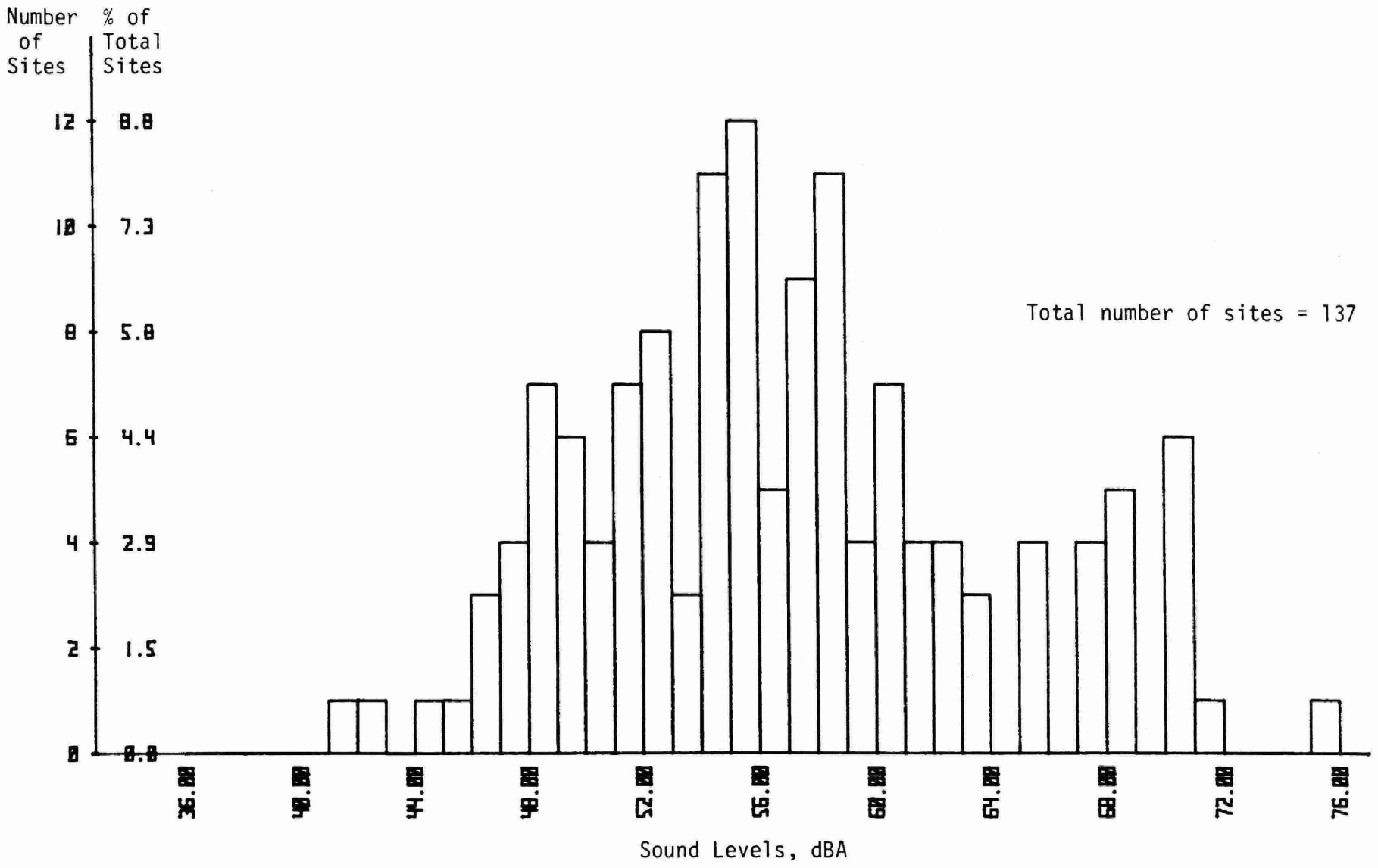

Figure 5.81 Night-time L_{10} Sound Levels at Residential Sites

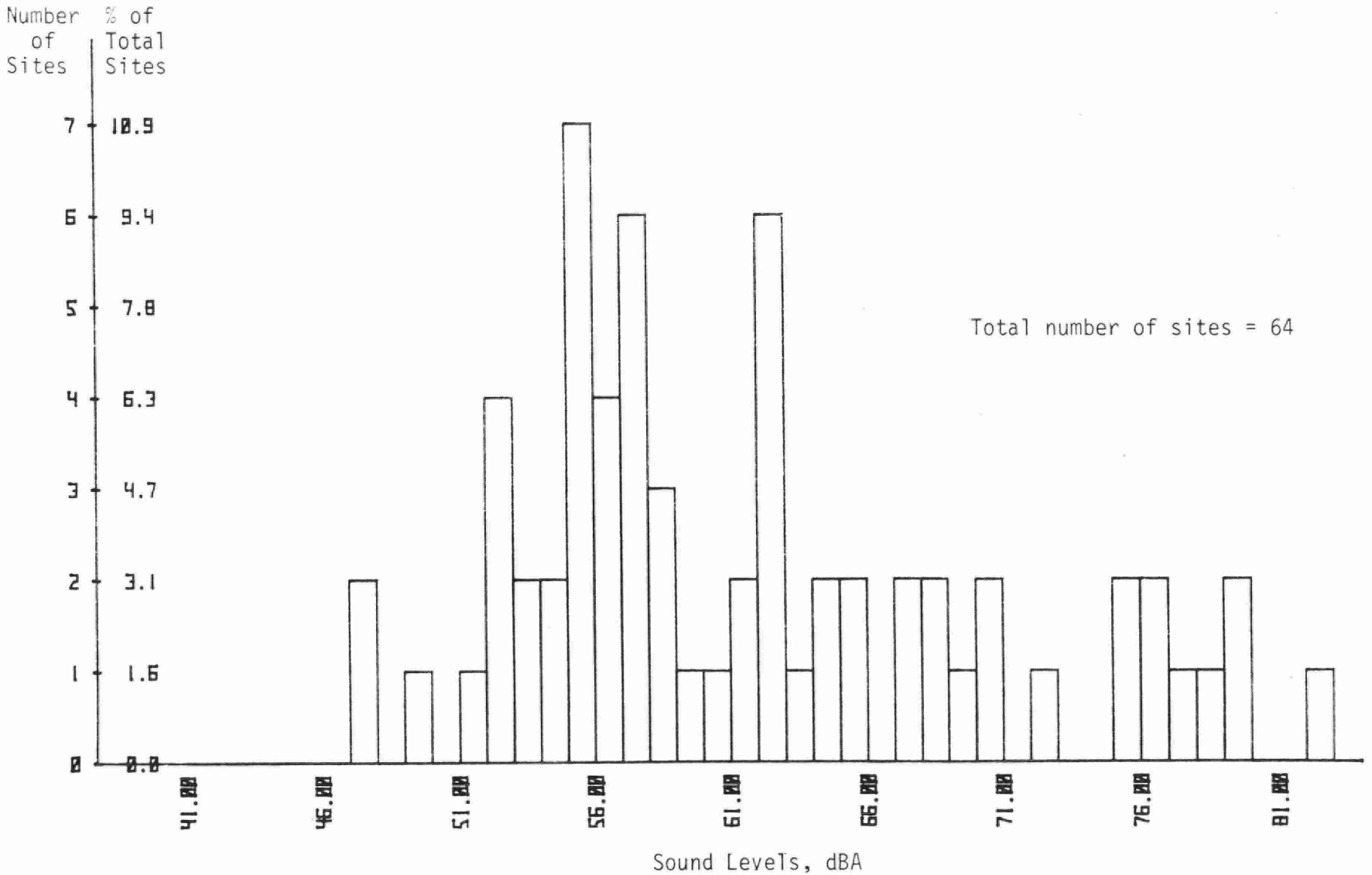

Figure 5.82 Daytime L_{eq} Sound Levels at Residential Sites

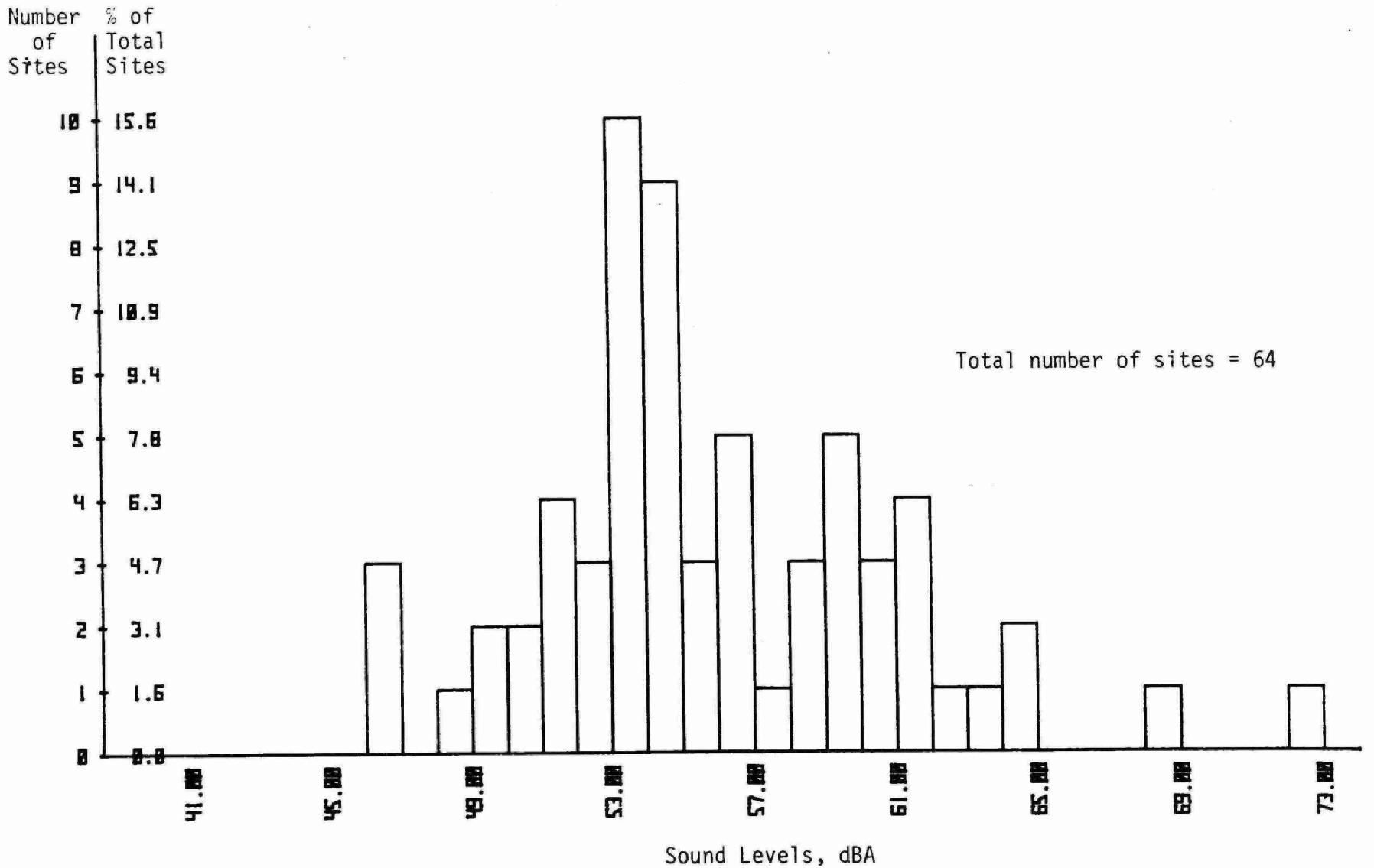

Figure 5.83 Evening L_{eq} Sound Levels at Residential Sites

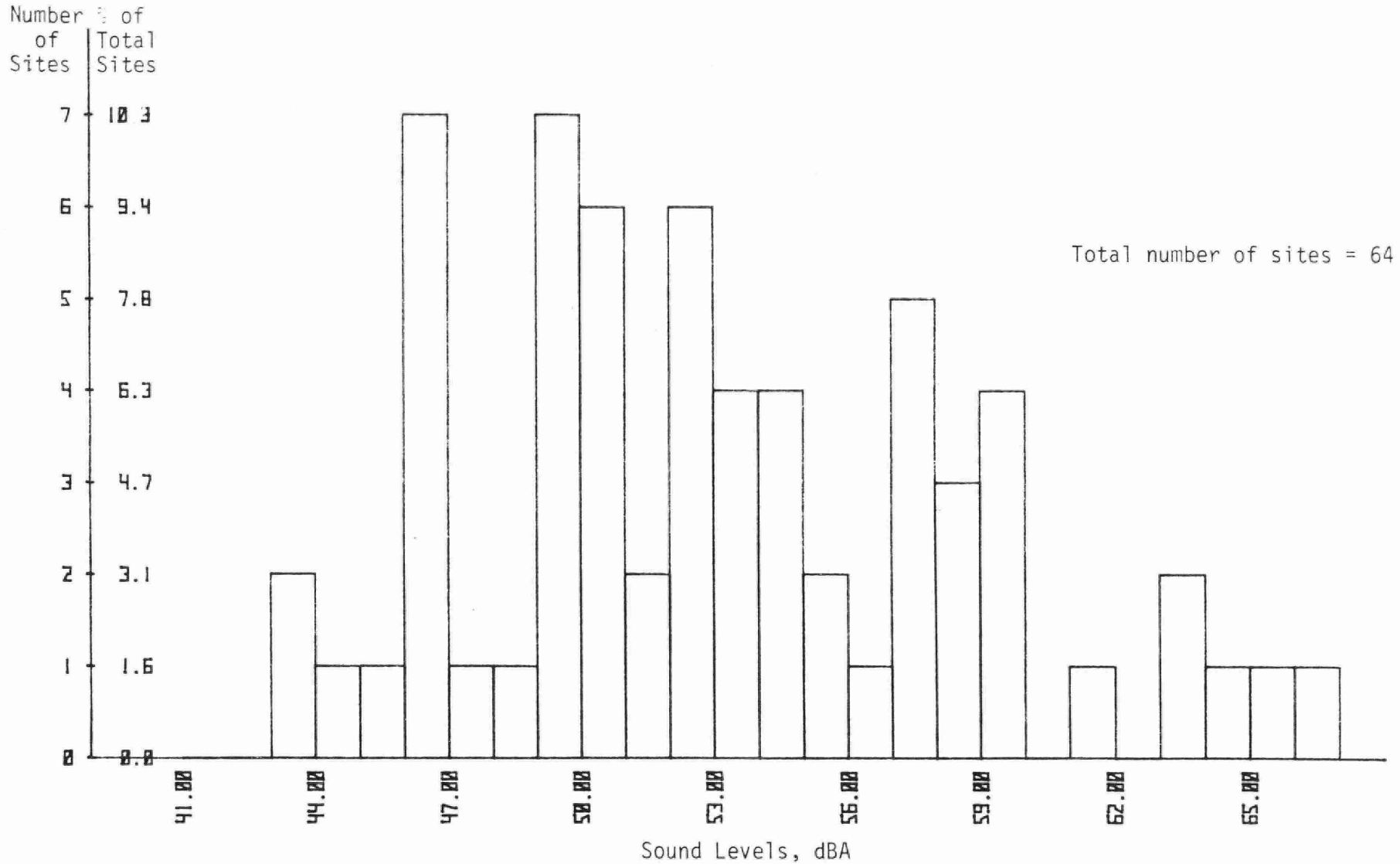

Figure 5.84 Night-time L_{eq} Sound Levels at Residential Sites

Sound level equal to,or less than,those given in the Table prevail at the indicated percentage of residential sites.

Descriptor	No. of sites	Sub-period	10% of sites			25% of sites			50% of sites			75% of sites			90% of sites		
			Set 1	Set 2	Average in dBA	Set 1	Set 2	Average in dBA	Set 1	Set 2	Average in dBA	Set 1	Set 2	Average in dBA	Set 1	Set 2	Average in dBA
L_{90}	137	Day-time	42.4	41.2	42	45.3	45.4	45	48.8	48.8	49	52.0	51.8	52	58.0	56.0	57
		Evening	41.4	39.9	41	43.8	43.3	43	47.3	47.5	47	50.7	50.4	51	54.0	54.0	54
		Night-time	38.1	36.6	37	40.9	40.5	41	44.3	44.7	44	48.2	48.5	48	51.2	51.5	51
L_{50}	137	Day-time	46.9	46.0	47	50.2	50.2	50	54.2	54.5	54	59.2	59.0	59	64.5	63.5	64
		Evening	46.1	45.3	46	47.8	48.7	48	51.2	52.2	52	55.5	56.0	56	60.4	60.7	61
		Night-time	43.0	41.3	42	45.4	45.0	45	48.4	48.3	48	52.1	52.2	52	55.0	56.3	56
L_{10}	137	Day-time	54.0	54.0	54	57.3	58.1	58	62.3	63.0	62	67.5	67.2	67	71.6	71.3	71
		Evening	51,3	51,3	51	54.2	54.6	54	59.0	59.0	59	64.6	64.2	65	68.5	68.0	68
		Night-time	48.9	48.4	49	51.2	51.9	52	55.8	56.0	56	60.6	60.7	61	67.4	67.8	68
L_{eq}	64	Day-time	52.1	52.8	52	56.0	55.8	56	59.3	59.0	59	64.0	67.5	66	76.5	76.3	76
		Evening	50.3	50.1	50	52.3	53.1	53	54.9	54.7	55	59.2	59.4	59	62.5	61.9	62
		Night-time	47.2	46.3	46	49.6	49.2	50	52.7	52.5	53	57.0	57.4	57	59.6	59.9	60

Table 5.4: Cumulative Distribution of Sound Levels at Residential Sites in Ontario.

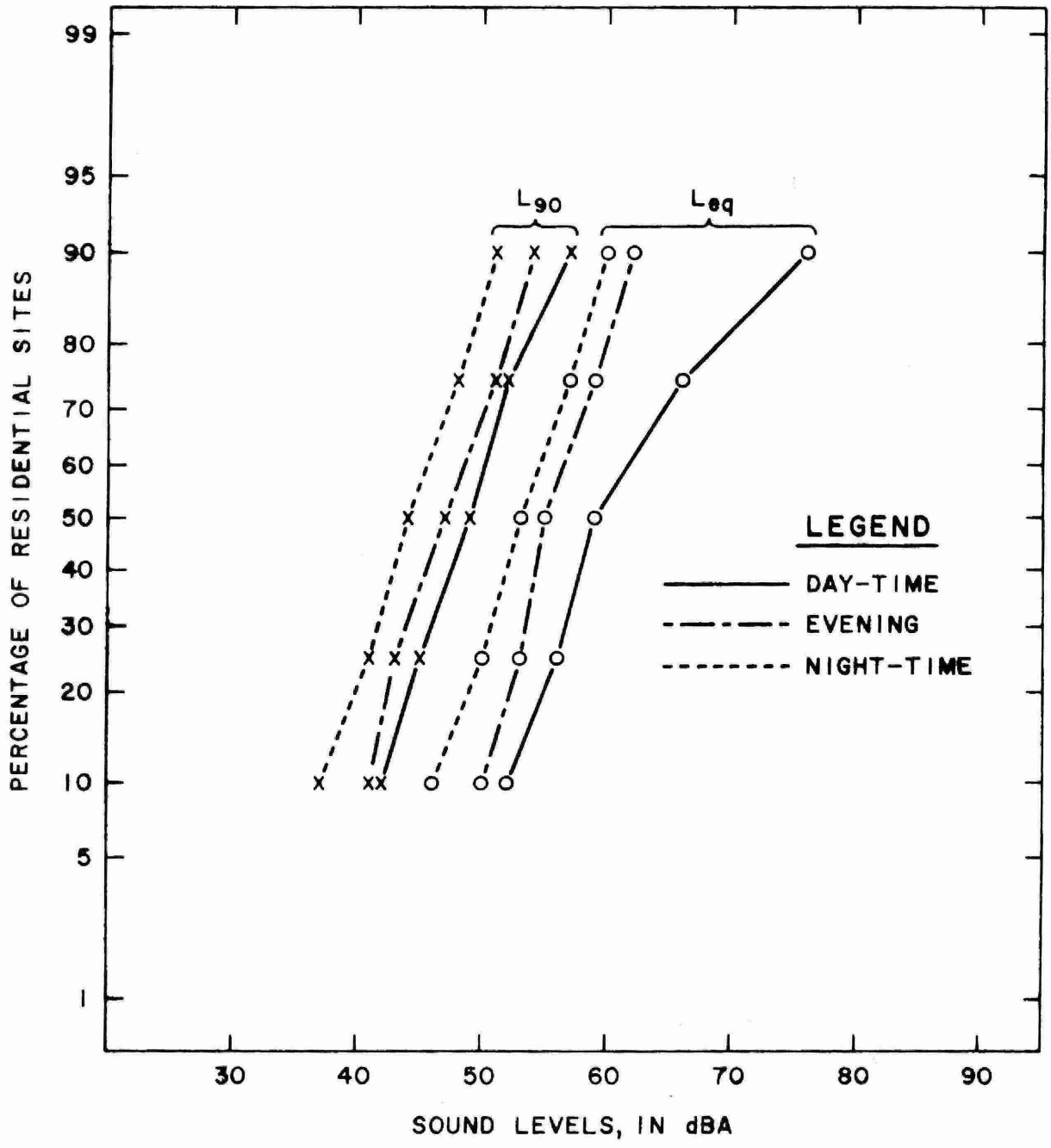

FIGURE 5.85 – OUTDOOR SOUND LEVEL EXPOSURE OF RESIDENTIAL SITES IN ONTARIO

Descriptor	Sub-Period	Day	Residential Zone			Residential-Commercial Zone		
			Mean levels, in dBA	Standard deviation	No. of sites	Mean levels, in dBA	Standard deviation	No. of sites
L_{90}	Day-time (7:00-19:00 hrs.)	First weekday	47.6	5.8	55	51.2	6.4	29
		Second weekday	47.5	6.0	55	49.8	6.6	29
		Saturday	47.5	5.7	38	50.4	5.1	25
		Sunday	45.5	4.8	39	48.1	4.8	27
	Night-time (23:00-7:00 hrs.)	First weekday	43.4	5.3	55	44.3	5.2	29
		Second weekday	43.6	6.2	55	44.1	6.9	29
		Saturday	43.0	4.0	38	47.0	6.1	25
		Sunday	41.7	4.2	39	44.0	5.3	27
L_{10}	Day-time (7:00-19:00 hrs.)	First weekday	60.3	7.0	55	64.8	6.8	29
		Second weekday	60.8	6.9	55	63.4	6.8	29
		Saturday	61.0	6.4	38	63.4	6.3	29
		Sunday	59.1	7.0	39	62.2	6.5	29
	Night-time (23:00-7:00 hrs.)	First weekday	54.7	6.7	55	59.2	7.3	29
		Second weekday	55.2	7.3	55	57.8	7.7	29
		Saturday	54.0	6.8	38	57.0	6.1	25
		Sunday	54.0	6.5	39	56.6	6.5	27

Table 5.5: Mean Sound Levels on Weekdays, Saturday and Sunday for Residential and Residential-Commercial Zones.

Type of Land-Use Zone	Sub-Period	Descriptor	City of Toronto			Other Communities		
			Mean levels, in dBA	Standard deviation	No. of sites	Mean levels, in dBA	Standard deviation	No. of sites
Residential	Night-time	L_{90}	45.6	5.0	100	43.4	5.3	55
		L_{50}	49.9	5.8	100	47.2	5.4	55
		L_{10}	57.4	7.6	100	54.7	6.7	55
	24-Hour	L_{90}	47.2	4.7	122	43.7	5.3	25
		L_{50}	54.8	5.7	122	48.5	4.7	25
		L_{10}	64.2	5.9	119	54.7	5.4	25
Commercial	Night-time *	L_{90}	53.4	5.4	27	46.3	3.7	11
		L_{50}	59.3	5.7	27	50.8	3.5	11
		L_{10}	68.0	5.6	27	60.1	4.5	11
	24-Hour	L_{90}	56.1	5.0	29	47.5	3.2	11
		L_{50}	66.0	5.1	30	57.1	4.0	11
		L_{10}	74.6	4.4	29	65.6	4.0	11
Industrial	Night-time *	L_{90}	57.2	5.5	27	55.7	8.8	12
		L_{50}	60.6	5.6	27	59.1	9.3	12
		L_{10}	66.4	6.5	27	65.6	8.8	12
	24-Hour	L_{90}	58.5	5.3	29	55.7	8.0	12
		L_{50}	64.3	5.4	29	61.0	7.8	12
		L_{10}	71.9	5.0	29	67.2	7.6	12

* For Toronto data, Night-time is 24:00-06:00 hrs.

Table 5.6 : Mean Sound Levels in the City of Toronto and other Ontario Communities

6. DISCUSSION

The analysis and the discussions presented in this report are confined only to those aspects of community noise considered to be of immediate relevance in preparing outdoor noise control limits for Ontario. Three major applications are The Model Municipal Noise Control By-law, Land-Use Planning Guidelines with respect to Noise and the Approvals Guidelines for Potential Noise Sources.

Sections 6.1 to 6.3 below discuss how community noise levels vary with the day of measurement, time of the day, land-use zoning and community population.

6.1 Weekday L_{90}, L_{50}, L_{10}, and L_{eq} Levels

From Tables 5.1 to 5.4, the following observations can be made regarding the weekday levels in the various land-use zones.

6.1.1. Day-to-Day Variations of Sound Levels: From Tables 5.1 to 5.3 the difference of mean levels between the two weekday measurements is generally less than 2 dBA in individual zones. This observation holds good for a wide range of sample sites (5 to 55). The same observation can be made independently, from the two sets of weekday data, shown as Set 1 and 2 in Table 5.4.

This finding suggests that the mean weekday levels in a land-use zone are practically independent of the choice of the monitoring day(s), although, at an individual site, the day-to-day levels may vary considerably.

In industrial zones, however, the variations of less than one dBA between daytime and night-time levels result from almost uninterrupted 24-hour industrial activity.

6.1.2 Time-of-Day Variations of L_{90}: Because of reduced background activity, night-time ambient levels are 2 to 4 dBA lower than the daytime levels in residential, residential-institutional, residential-industrial and institutional zones. The higher variations (4-6 dBA) noted for residential-commercial and commercial areas signify the presence of heavier daytime traffic flow in these areas as compared with residential or institutional types of mixed zones.

6.1.3 Time-of-Day Variations of L_{10} and L_{eq}: Land-use characteristics with levels are less clearly and less consistently defined by L_{10} and L_{eq} data than by L_{90} data above. In general, night-time levels are lower than the daytime levels by 5 to 7 dBA for L_{10} and 8 to 11 dBA for L_{eq}, respectively. For L_{eq}, these varying values are approximately 3 dBA in industrial sites, and 4 dBA in institutional zones.

Because of the reliable predictability with which L_{90} changes with the types of land-use and the sub-periods, it emerges as a preferred descriptor over L_{10} and L_{eq} to acoustically describe the type of zones in a community.

6.1.4 L_{90}, L_{10} and L_{eq} Levels in Land-Use Zones: The weekday levels in residential, residential-institutional, residential-industrial and institutional areas are lower than those of residential-commercial, commercial, industrial and residential-commercial-industrial zones. This difference results from high levels of traffic flow occurring in commercially oriented zones, and high sound levels produced at industrial sites. The lowest levels were measured in residential and institutional zones (mean L_{90}: 43-48 dBA, mean L_{10}: 52-61 dBA and mean L_{eq}: 51-60 dBA), and the highest levels, in commercial and industrial areas (mean L_{90}: 46-58 dBA, mean L_{10}: 60-68 dBA and mean L_{eq}: 58-68 dBA).

The site variance,which is a measure of site-to-site variation of levels,was found to be minimum in institutional zones (standard deviations of L_{90}: 3-5 dBA, L_{10}: 5-6 dBA and L_{eq}: 5-6 dBA), and commercial zones (standard deviations of L_{90}: 3-4 dBA, L_{10}: 4-5 dBA and L_{eq}: 4-5 dBA), and a maximum in industrial zones (standard deviations of L_{90}: 8-10 dBA, L_{10}: 7-9 dBA and L_{eq}: 8-9 dBA).

Because of their measured low levels together with their low site-to-site variance, institutional zones are generally the quietest areas in a community, and experience fewer noise events.

The reason for low variance noted between commercial locations is not clear, but it is possible that the small number of measured sites were all selected in areas of similar commercial activity.

A wide range of industrial activity encompassed by a small number of monitoring sites explains the high variance noted for industrial zones.

Generally, mean sound levels and site variances of purely residential zones are not significantly different from those of institutional, residential-institutional and residential-industrial areas, at the 5% level of significance. This finding suggests that, in general, the above four land-use categories can be treated as a single category in the analysis of community noise.

6.1.5 Sound Level Exposure of Residential Areas in Ontario: To determine the noise-climate of residential districts in Ontario, the data of residential, residential-institutional, residential-commercial and residential-industrial zones were aggregated for analysis. The percentile catagories of Table 5.4 refer to the various degrees of residential activity in communities (population range: 25,100 - 220,000). The choice of these percentages is somewhat arbitrary, and other numbers selected may have served equally well.

L_{90} and L_{eq} data of Table 5.4 are presented in the form of a cumulative distribution graph in Figure 5.85. The L_{90} and L_{eq} levels exposure of any required percentage of residential sites can be determined from this graph. As an example, 25% of the measured sites experience a daytime L_{eq} level of up to 56 dBA. Conversely, the remaining 75% of the sites are exposed to levels higher than 56 dBA. The high level short duration intrusive sounds present at the noisier sites greatly increase L_{eq} levels, but hardly affect L_{10} or L_{90} levels. The abrupt divergence, observed for the daytime L_{eq} curve in the figure 5.85, is caused by this effect.

A note concerning the scope of the application of data shown in Table 5.4 will be relevant here. The reported levels represent the roadside measurements, and should not be interpreted as the levels prevailing in the backyards or at the facades of residential dwellings. In these cases, the levels would be generally lower than the values given in Tables 5.4; the discrepancy is expected to be higher for L_{eq} and L_{10} than for L_{50}, and practically negligible for L_{90}.

Further, it should be pointed out that levels experienced in the residential areas close to major or busy freeways, railway routes or aircraft flight-paths are not adequately represented in the data collected here.

6.2 Weekday vs. Weekend Levels

From Table 5.5, levels on Saturday were generally noted to be within one dBA of the weekday values, except in residential-commercial area, where increased shopping activity on Saturday raised L_{10} levels by approximately 3 dBA.

Sunday levels were approximately 2 dBA lower than the weekday levels, because of reduced community activity.

Night-time and 24-hour levels and site variances in industrial zones of Toronto are not significantly different from those of other cities, at the 1% level of significance. Thus, levels in industrial zones are insensitive to the size of community.

Further, levels in the commercial zones of Toronto are higher than those of other communities due to the higher transportation and commercial activity.

6.3 Levels in the City of Toronto vs. Other Cities

To observe the dependence of sound levels on the size of the community, levels measured in the City of Toronto (population: 686,000) were compared against those of other cities (population range: 25,100 to 220,000) in the Table 5.6.

Night-time levels and site variances of residential zones in Toronto are significantly different from those of Kingston, North Bay, Sault Ste. Marie, London and Woodstock, at the 5% level of significance. However, these differences are not significant at the 1% level of significance.

Both the higher 24-hour levels, and about equal night-time levels noted for Toronto (in comparison with other communities) suggest that the daytime levels prevailing in smaller cities are lower.

The above discussion indicates that the night-time levels at residential sites are somewhat independent of the size of the community, and result from reduced night activities. Daytime noise-climate is characterized by the noise events occurring at a site.

7. CONCLUSIONS

1. Mean weekday levels within a particular land-use category are practically independent of the choice of the monitoring day(s), although considerable day-to-day variations in sound levels may occur at any one site.

2. The variations between the daytime and night-time levels are most pronounced in commercially oriented zones, and the least pronounced in industrial zones.

3. Of the three descriptors (L_{90}, L_{10} and L_{eq}) analysed here, L_{90} changes most predictably over the different land-use zones and the times of the day.

4. The highest levels are measured in industrial and commercially oriented zones; institutional zones are the quietest areas in a community.

5. Mean sound levels and site variances of purely residential zones are not significantly different from those of institutional, residential-institutional and residential-industrial zones, at the 5% level of significance.

6. Sunday mean levels are approximately 2 dBA lower than the weekday levels in individual land-use zones. Saturday levels, however, are approximately the same as the weekday levels.

7. Night-time levels and site variances of residential areas in the City of Toronto (population: 686,000) are not significantly different from those of Kingston, North Bay, Sault Ste. Marie, London and Woodstock (population range: 25,100-220,000), at the 1% level of significance. A similar trend is also noted for the night-time and 24-hour levels of industrial zones. However, day-time levels in residential areas of the City of Toronto are higher than the corresponding levels of the smaller communities.

8. RECOMMENDATIONS FOR FUTURE WORK

The following specific areas are recommended for future investigation.

1. The dependence of sound levels on community size be systematically studied.

2. The correlationships between the various community noise descriptors (L_1, L_{10}, L_{50}, L_{90}, and L_{eq}) be investigated.

3. A systematic study be undertaken to determine the validity of a 24 - hour L_{eq} and L_{dn} (24-hour L_{eq} level in which a 10 dB penalty is added to night - time levels) as possible community noise measurement indices.

4. A complete comparison of weekday versus weekend levels be undertaken, by including the data of all the land-use zones.

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APPENDIX I	-	Community Noise Level Data of Kingston
APPENDIX II	-	Community Noise Level Data of North Bay
APPENDIX III	-	Community Noise Level Data of Sault Ste. Marie

Copies of the Appendices on Community Noise Level Data are available.
Price for each volume of data is $5,00.
A cheque or money order payable to the "Ministry of the Environment" must accompany each order mailed to:

Ministry of the Environment
Supervisor
Noise Pollution Control Section
135 St. Clair Ave. West, 7th Floor
TORONTO, Ontario M4V 1P5

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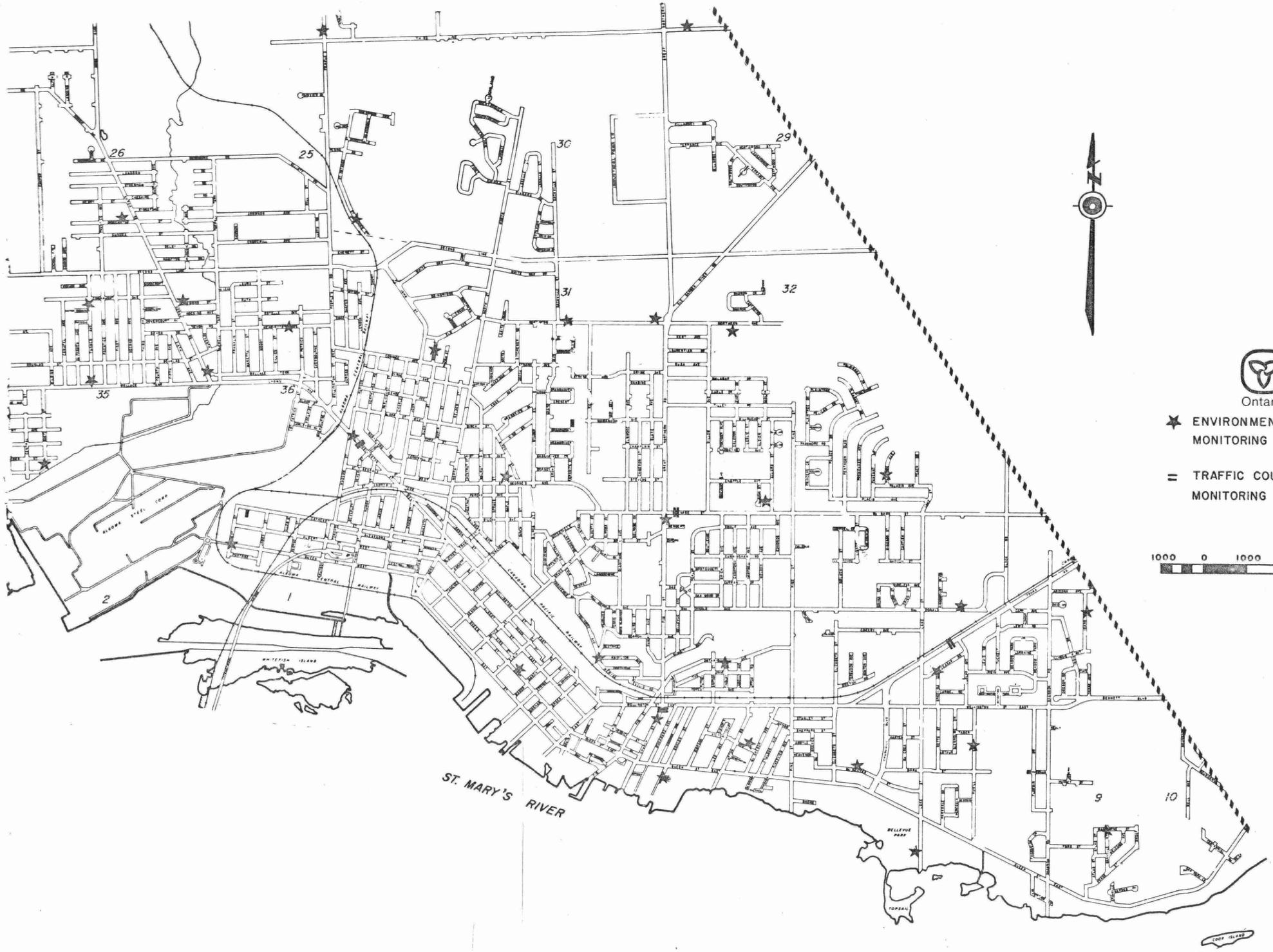

COMMUNITY NOISE MONITORING SITES IN CITY OF SAULT STE. MARIE

BASE MAP PREPARED BY SAULT STE. MARIE AND SUBURBAN AREA PLANNING BOARD

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COMMUNITY NOISE MONITORING SITES IN CITY OF KINGSTON

BASE MAP PREPARED BY CITY OF KINGSTON PLANNING DEPARTMENT

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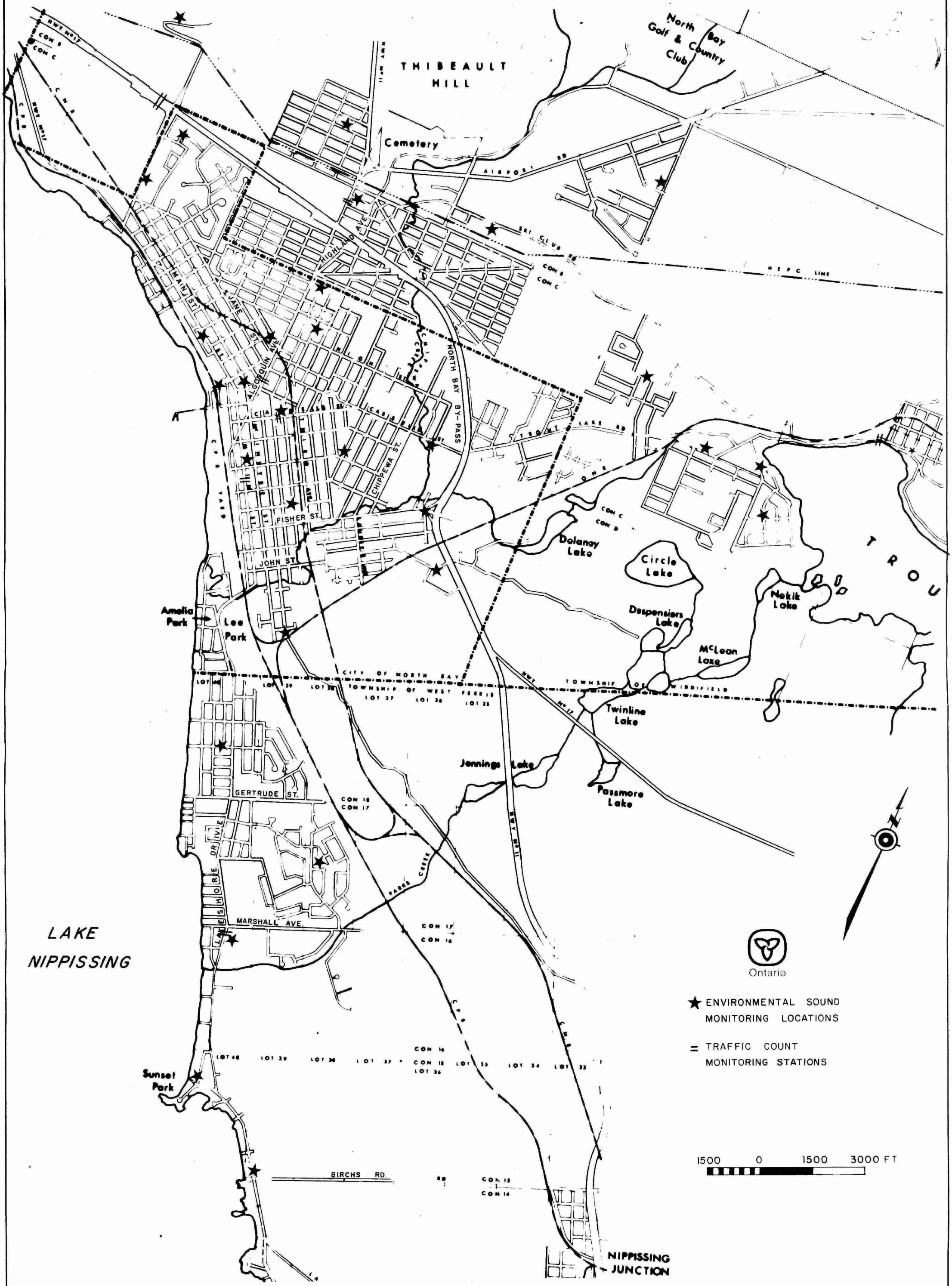

BASE MAP PREPARED BY CITY OF NORTH BAY

COMMUNITY NOISE MONITORING SITES IN CITY OF NORTH BAY

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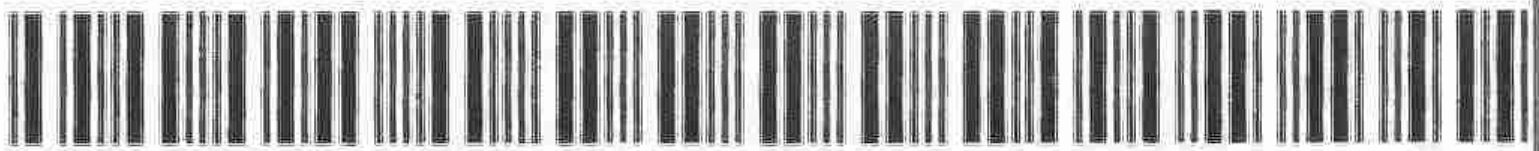
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